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INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr' a
10^{9}	giga	G	jĭ' ga
10^{6}	mega	M	mĕg' a
10^{3}	kilo	k	kĭl' o
10^{2}	hecto	h	hĕk' to
10	deka	da	dĕk' a
10^{-1}	deci	d	dĕs' i
10^{-2}	centi	c	sĕn' ti
10^{-3}	milli	m	mĭl' i
10^{-6}	micro	μ	mi' kro
10^{-9}	nano	n	năn' o
10^{-12}	pico	p	pē' co
10^{-15}	femto	f	fĕm' to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

RADIOLOGICAL HEALTH DATA AND REPORTS

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In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

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Published under the direction of

James G. Terrill, Jr., Director and
Dr. Raymond T. Moore, Deputy Director
National Center for Radiological Health

by the Standards and Intelligence Branch
Donald L. Snow, Chief

Address correspondence to the Managing Editor, *Radiological Health Data and Reports*, National Center for Radiological Health, Public Health Service, Rockville, Md. 20852.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service ● National Center for Radiological Health

Reports

Levels of Iron-55 in Humans, Animals, and Food, 1964–1967[1]

H. E. Palmer[2], *J. C. Langford*[2], *C. E. Jenkins*[2], *T. M. Beasley*[2], and *J. M. Aase*[3]

Iron–55 levels in the foods of humans have been decreasing since 1964 with the exception of caribou obtained from Arctic areas, which showed peak levels in 1965. The levels of iron–55 in humans at Richland, Wash., increased until about January 1967, and then began to decrease. This peak level in humans occurred about 4 years after the 1962 nuclear test series. This lag time of 4 years is much longer than that for cesium–137 in humans where peak levels occurred 1½ years after the nuclear tests stopped.

The relatively high abundance of the activation product iron–55 in the fallout from the 1961–1962 nuclear tests resulted in a deposition of this isotope on the earth's surface which at one time was comparable to or slightly higher than the strontium–90 and cesium–137 levels (*1*). However, the relative amount of iron–55 in the environment has decreased much more rapidly than strontium–90 and cesium–137 because of its shorter half-life of 2.4 years.

Because of the high uptake of fallout iron–55 in the food chains leading to humans, it can be measured in people all over the world (*2*, *3*, *4*). Although the energy of the radiation emitted as a result of the disintegration of an atom of iron–55 is small, it is of interest because most of the radiation dose is absorbed by the red blood cells of the body (*5*).

The two main routes of iron–55 to humans are the terrestrial food chain of plant to animal to man and the marine food chain from sea water through the lower trophic levels to fish to man. The purpose of this paper is to discuss the levels of iron–55 in the components of these food chains, and the changes in these levels during the past few years, and to compare the rate of uptake by man of this isotope with that of cesium–137.

Iron–55 in the marine environment

A preliminary survey of iron–55 in the most common foods consumed by people showed that ocean fish contain a higher concentration of iron–55 than do many other foods (*3*). Salmon and tuna were among the fish having the highest concentrations. For both of these fish the concentrations increased in the more northern latitudes. This change in concentration with latitude has been observed for the past 4 years and table 1 lists the levels in salmon at various locations. The highest concentrations observed in salmon were from those caught at Kotzebue, Alaska.

Table 1. Levels of iron–55 in salmon caught at various locations from 1965 to 1967

Sampling location	Average (nCi iron-55/kg of wet muscle)		
	1965	1966	1967
Northeast Alaskan coast	[a] (2)50	(44)19	(10)5.0
Southern Alaskan coast	(4)33	(14)25	(17)5.6
Washington State coast	(2) 9.0	(6) .91	(10)1.5

[a] Numbers in parentheses are the number of salmon included in the average.

The data in table 1 are averages of several species and include silver, sockeye, chinook, and chum salmon. Our studies do not yet show any definite differences in iron–55 content in any particular species. The decrease of iron–55 in

[1] This paper is based on work performed under United States Atomic Energy Commission Contract AT (45–1)–1830.

[2] Pacific Northwest Laboratory, operated by Battelle Memorial Institute for the Atomic Energy Commission, Richland, Wash.

[3] Arctic Health Research Center, Anchorage, Alaska. Present address: University of Washington Medical School, Seattle, Wash.

the salmon with time is about the same or slightly more rapid than the decrease in the fallout rate, as measured from air and rain concentration, both in the United States and Alaska. This suggests that the iron–55 deposited in the ocean may be rapidly taken up by the biomass and becomes relatively unavailable for further recycling into the salmon.

Other recent studies (*6*) confirm our results of yearly decreases in salmon levels since 1964 and the increased concentration at northern latitudes. The reason for the relatively high iron–55 levels in salmon is not entirely clear and the route of intake has not been well established. Recent studies at our laboratory have shown that the iron–55 specific activity in salmon (μCi of iron–55/g stable iron) is 1,000 to 10,000 times greater than in the particulate fraction of sea water. Iron is present in sea water in about half particulate and half soluble form (*7*). This sea water was filtered through a 0.3 micron pore size membrane filter at a point 15 miles off the northern California coast away from any major river influence where the salinity and the stable iron content were normal. This suggests again that the iron–55 from fallout is in a form which is more readily available for uptake in the marine food web than the stable particulate iron in the ocean.

Iron–55 in humans

It has been shown that whole population groups including the Japanese, the Scandinavians and the Southeast Alaskan Eskimos, who eat large quantities of ocean fish, have far higher iron–55 body burdens than the average for other people in the world (*3, 4*). It has also been observed that females of these population groups have higher burdens than the males and that the specific activity of iron–55 remains constant on transfer from mother to fetus. The nature of this transfer of iron–55 from mother to fetus was characterized in a study during 1967 of 50 mother-fetus pairs from an area surrounding Dillingham, Alaska (results to be published elsewhere). The specific activity of the mother's blood was essentially the same as that in the baby's cord blood at birth except in 2 or 3 cases. The average specific activity for all the mothers and all the newborn babies was approximately 0.10 nCi/mg when decay was corrected to January 1967. Assuming a total iron content of 4,000 mg, the average body burden was 400 nCi for the adult females in that area during January 1967, as compared with an average body burden of 700 nCi measured in a similar group of fish-eating female natives from the Bethel Alaska area in early 1966.[4]

Iron–55 in the terrestrial environment

The main source of iron–55 in the diets of most of the people of the world is from meats and grains. The decrease of iron–55 with time, resulting from the plant to animal to man food chain is shown in table 2 where the levels of iron–55 in the blood of cattle near Richland, Wash., are listed for the years 1964–1966. This decrease with time in the iron–55 content of cattle is slightly less than the decrease in fallout rate. This relationship is probably due to the fact that grass and other cattle feeds collect most of their iron–55 directly from the atmosphere. The iron–55 which reaches the soil undergoes tremendous dilution by stable iron in the soil, and only a small fraction is absorbed by the plants. An exception to this type of relationship is the food chain of lichen to caribou to man where the lichen does not die off each year but collects and holds a large fraction of the fallout for a period of years and provides a more concentrated source of iron–55 to the caribou. For this reason, the caribou blood levels increased for a period of years and then decreased as the radioactive decay exceeded the deposition of iron–55 on the lichen from fallout (table 3).

Table 2. Total body iron–55 contents [a] in 1,000 lbs. steers raised near Richland, Wash., 1964–1966

Sampling date	Number of steers	Average body burden (nCi)
November 1964	8	441
November 1965	4	226
December 1966	10	108
March 1968	20	44

[a] Body burden determined from blood samples by assuming 60 percent of iron is in the blood.

[4] Considering the 2.4-year half-life of iron–55, this reduction is close to the value based on physical decay.

Table 3. Total body iron-55 [a] in caribou from Anaktuvuk Pass, Alaska, 1964–1967

Sampling date	Number of caribou	Average body burden (nCi)
November 1964	5	744
February 1965	6	714
October 1965	6	953
May 1966	6	654
January 1967	10	670
March 1968	6	481

[a] Body burden determined from blood concentration by assuming 60 percent of iron is in the blood.

Iron–55 in foods and humans

The decrease in iron–55 levels in common foods purchased at local Richland, Wash. stores between December 1964 and April 1967 are shown in table 4. This time interval is 2.4 years which is the same as the half-life of iron–55 and, therefore, the 1967 results can be multiplied by a factor of 2 to correct for the radioactive decay since 1964. If this is done the overall average for the foods measured in this study for 1967 would be about the same as the overall average in foods for 1964. This result does not agree with those obtained in the cattle (table 2) and salmon (table 1) where the concentrations are significantly lower in 1967 even after a decay correction is made. One possible explanation for the similarity between the results for the 1964 grain product samples and the 1967 samples is that the earlier samples may have been from stored grain which had been harvested prior to the 1962–1963 peak fallout levels. Another possible explanation for the similarity is that the geographical source of the raw materials differed in 1964 from 1967.

The body burdens of iron–55 in people in Richland, Wash., have been determined for the past 4 years by measuring the levels in blood samples taken at hospitals and Red Cross blood drawings. The blood left in the plastic tubing after the blood samples are taken in blood donations is sufficient for measuring iron–55 if these are collected and combined for at least 25 people. The body burdens in Richland adults at various times are listed in table 5. The four people in the first two samplings were the same people and it is obvious that their average body burdens of iron–55 were lower than the average for 100 men obtained a few months later. The results do demonstrate an increasing body burden until the July 1967 sample which showed that the levels had started to decrease. The similarity of the Richland female and male body burdens is typical of results obtained from blood bank samples. Previous sampling of non-blood bank male and female blood indicates that iron–55 levels measured in females may be two times higher than males of the same population (*2*). These differences indicate that the iron uptake and turnover in women is significantly greater than in men. Consequently, the iron–55 activity in females after the initial environ-

Table 4. Comparison of iron–55 in various foods purchased at Richland, Wash., in 1964 and 1967

Food	1964			1967		
	Stable iron (mg/kg)	Iron-55 (nCi/kg)	Specific activity (nCi/mg)	Stable iron (mg/kg)	Iron-55 (nCi/kg)	Specific activity (nCi/mg)
Beef, round steak	23	0.70	0.030	23	0.24	0.010
Beef, liver	70	1.1	.016	100	1.45	.015
Bologna	9.1	.34	.037	14	.083	.006
Weiners	12	.21	.018	25	.33	.013
Pork chops	6.7	.013	.002	10	.007	.0007
Pork and ham loaf	16	.060	.004	9.7	.047	.005
Washington coast:						
Salmon	5	3.42	.68	11	1.5	.14
Pacific ocean:						
Tuna	4.6	5.8	1.26	8.6	3.7	.43
Clams	17.7	.045	.003	26	.046	.002
Oysters	170	.087	.0005	68	.075	.001
Whole wheat flour	38	.29	.008	38	.23	.006
White flour	31	.044	.001	40	.006	.0002
Wheat flakes	56	.25	.004	54	.12	.002
Quaker oats	41	.15	.004	52	.093	.002
Eggs	23	.25	.011	23	.013	.0006
Lettuce	4.5	.011	.002	8.5	.0014	.0002
Carrots	4.1	.028	.007	8.4	.0006	.00007

mental exposure would reach a maximum earlier than males and then rapidly decline to levels below the male population. Women who have the highest iron uptake are usually those who are more anemic and these women are not allowed to donate at blood banks. Therefore, blood bank samples do not represent the average iron–55 levels in women, and it is also possible that regular male blood donors do not represent the normal population since their regular blood loss through donation will increase their rate of iron turnover.

The body burdens in the male Eskimos on caribou diets at Anaktuvuk Pass, Alaska, increased during 1965; body burdens of 61 nCi were observed in January and 81 nCi in November. Samples at later dates have not been obtained, but the levels in the caribou which they eat and the long biological half-life in the body suggests that the levels in these Eskimos have continued to increase until recently.

Although the major nuclear testing by the United States and U.S.S.R. was stopped in 1962, the levels in humans in Richland, Wash., did not reach peak values until the latter part of 1966 or early 1967. This 4–year lag is probably caused by (1) the time for the fallout to reach the earth's surface and transfer through the food chain, and (2) the long biological half-life in humans which allows the levels in humans when not near the equilibrium level, to continue to increase for a period of time after the levels in the food have begun to decrease. This lag time is about 2½ years longer than that for cesium–137 in humans in Richland, Wash., where the peak levels were reached during mid 1964. This is reasonable when the shorter biological half-life of cesium–137 in humans and in the various components of the food chain is considered. If the iron–55 levels are corrected for radioactive decay, the lag time for the peak levels in humans after injection of iron–55 in the atmosphere would be somewhat longer than that shown by the actual levels.

Table 5. Total body iron–55 in adults in Richland, Wash.

Sampling date	Male		Female	
	Number of individuals in composite samples	Average body burden (nCi)	Number of samples	Average body burden (nCi)
November 1964	4	9	—	—
October 1965	4	13	—	—
January 1966	100	21	25	16
March 1966	—	—	25	18
December 1966	100	24	25	22
July 1967	84	17	—	—

Summary

Iron–55 levels in fallout and most foods have been decreasing since 1964. The relative decrease in some of these components of the human food chain and fallout is shown in figure 1. The levels in humans have been increasing until recently when they showed a decreasing trend.

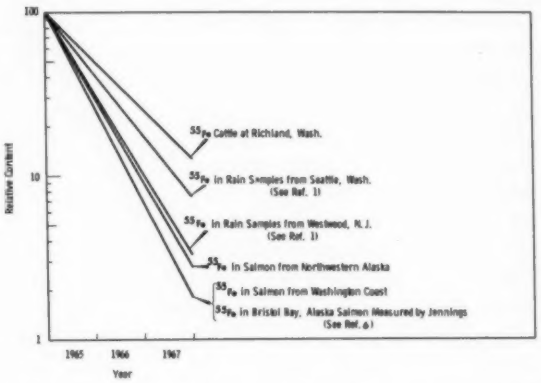

Figure 1. A comparison of the relative decrease of iron–55 in fallout, salmon, and cattle

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Cesium–137 Levels in Florida Beef—Variations With Feeding Program[1]

C. E. Roessler, B. G. Dunavant, H. A. Bevis, and *G. S. Roessler*[2]

Levels of cesium–137 in low quality lean beef samples, collected in the vicinity of Gainesville, Fla., in the spring of 1967, averaged 4,000 pCi/kg and ranged from 290 to 12,500 pCi/kg. The average and maximum levels in these samples from eight grass-fed animals were considerably higher than those in samples from 26 grain-fed animals from five peninsular Florida feedlots. The levels in the grass-fed animals suggest very high levels of cesium–137 intake by the animals, an extremely high feed-to-meat transfer, or both. For persons whose meat consumption is represented by the grass-fed animals examined in this study, it can be expected that meat exceeds all other commodities as the source of cesium–137 intake.

This paper reports observations of the effect of feeding program and associated meat quality on the levels of environmentally accumulated cesium–137 in Florida beef sampled during 1967 (figure 1).

From examination of reported data, it appears that cesium–137 levels in Florida milk have a consistent geographic pattern (*1*).[3] This impression can be confirmed by statistical testing and similar patterns can be found in feedlot beef.[4] Levels in these two media in peninsular Florida (the general area encompassing the northeastern, central, and southern parts of the State) were higher than in the western part of the State and were higher than reported or anticipated average levels in comparable media from the conterminous United States.

Porter has reported that cesium–137 levels in milk from the Tampa, Fla. milkshed have considerable farm-to-farm variation (*2*); in other studies, this variation has been found throughout the State.[5] These variations have been attributed to variations in levels of cesium–137 intake by the animals, and locally grown forages have been identified as major contributors to the elevated intake of this nuclide.

During a study of geographic variations in feedlot beef,[4] some examples were collected also from lower grade carcasses of animals whose feed included various amounts of grass. This provided an opportunity to determine whether feed source has the same effect on cesium–137 levels in Florida beef as it apparently has on levels in milk.

Methods

During the spring of 1967, samples from eight locally fed animals were obtained from a commercial packing plant in the Gainesville,

Figure 1. Florida beef sampling locations

[1] This work was supported in part by U.S. Public Health Service Grants No. 5–T1RH3–07 (67) and No. 3–T1RH30–04S1 (66).

[2] Dr. C. E. Roessler is assistant professor of Radiation Biophysics (Department of Radiology); Dr. Dunavant is director and professor of Nuclear Sciences; Dr. Bevis is associate professor of Environmental Engineering; and Mrs. Roessler is instructor in Nuclear Sciences, University of Florida, Gainesville, Fla. 32061.

[3] C. E. Roessler, E. G. Williams, and E. D. Nettles, University of Florida and Florida State Board of Health, submitted for publication.

[4] C. E. Roessler, B. G. Dunavant, and H. A. Bevis, to be published in *Health Physics.*

[5] Work performed at Florida State Board of Health and at the University of Florida.

Fla. vicinity. This meat was of a lower quality than meat usually sold as retail cuts and was intended for ground beef and meat products (frankfurters, bologna, etc.). Four of these samples were collected in April and were identified only as "two had some grain, two fed primarily grass." In May, the four additional samples were collected from the same packing plant along with available identifying information. All of these latter animals were cows of various breeds, the meats were low grades, and two samples were specifically identified as from grass-fed animals while two were from animals that had some grain. The packing plant samples were collected in the cutting room from animals selected by plant personnel and when picked up in the shipping department were not identified as to portion of animal. The assumption was made that the cesium–137 content of any lean portion sampled was representative of consumed lean tissues of that animal and could be compared with results from analysis of different portions of other animals.

Samples were also collected during January through June 1967, from 26 carcasses graded USDA Good or USDA Choice from animals fed at Florida Agricultural Experiment Station feedlots at the five locations shown in figure 1.[4] Two of these latter animals were from a feedlot in the Gainesville vicinity. The other animals were from sites scattered throughout penisular Florida. (See part C of table 1). These samples were obtained through the University of Florida Meat Laboratory; the carcasses were sampled by collections of the portion associated with the 13th rib (3 to 4 inches of a short loin).

Samples were prepared for analysis by boning, trimming the excess fat, and grinding the trimmed lean portion.

Analyses for cesium–137 and potassium–40 were performed by gamma-scintillation spectrometry followed by quantitiative evaluation of the gamma-ray spectra using the method of simultaneous equations. Cesium–137 concentrations were reported as picocuries per kilogram (pCi/kg) and as picocuries per gram of potassium (pCi/g K).

Results

As shown in part A of table 1, the first four packing plant samples (Nos. 36–39) had cesium–137 contents ranging from 290 to 12,500

Table 1. Variation of cesium–137 content of lean Florida beef as influenced by feeding program and grade of meat

Sample number	Animal description	Feed	Meat grade	Cesium-137 (pCi/kg)	Potassium (g/kg)	Cesium-137/ potassium (pCi/g)
A. Samples from local packing plant buying only local animals (trimmed from unidentified portions) [b]						
			Collected April 26, 1967			
36	4 animals identified only as "two had some grain, two fed primarily on grass"			293 ± 24 [a]	3.24 ± .24 [a]	90.4 ± 9.9 [a]
39				507 ± 29	3.51 ± .27	144.0 ± 13.7
37				1,840 ± 36	3.69 ± .27	498.0 ± 37.8
38				12,500 ± 73	3.36 ± .28	3,710.0 ± 309.0
			Collected May 10, 1967			
50	Hereford cow	Some grain	Utility	567 ± 27	3.90 ± .26	145.0 ± 12.0
53	Hereford cow	Some grain	Cutter	808 ± 41	4.09 ± .38	198.0 ± 21.2
52	Jersey-cross cow	Grass-fed	Not specified	5,530 ± 68	4.97 ± .40	1,130.0 ± 97.2
51	Brahma cow	Grass-fed	Canner	9,840 ± 64	3.62 ± .27	2,720.0 ± 200.0
			Average of 8 animals	3,990	3.80	1,080.0
			Range	293 – 12,500	3.24 – 4.97	90.4 – 3,710
B. Samples from University of Florida Beef Research Unit (trimmed from short loin)						
			Collected January 7, 1967			
7	Steer	Dry lot: corn, and	Good	204 ± 29	3.75 ± .30	54.3 ± 8.9
8	Steer	Citrus pulp	Good	142 ± 24	3.31 ± .24	42.6 ± 7.8
			Average of 2 animals	173	3.53	48.5
C. Samples of feed-lot animals from five peninsula Florida stations (trimmed from short loin)						
			Collected January-June 1967			
	Steers and heifers	Dry lot	Good and choice			
			Average of 26 animals	240	3.58	66.1
			Range	109 – 539	3.09 – 4.22	30.4 – 133.6

[a] Confidence intervals represent the two-standard deviation counting error only and do not include other sources of variance.
[b] Comments concerning feed of these animals were supplied by packing plant. They are probably based on condition of animals and appearance of meat.

pCi/kg (90 to 3,710 pCi/g K). These four samples from the same general geographic locality had a wider range of cesium–137 levels than all the statewide beef samples analyzed previously in this laboratory. Type and source of feed seemed to be the most likely explanation for the degree of variation, and it was suspected at this point that the highest cesium–137 levels were from the animals whose diets were composed primarily of grass. In order to verify that such a wide variation in results was not a rare chance occurrence, the four additional samples (Nos. 50–53), also listed in part A of table 1, were collected from the same source. It can be seen that the range of results was very similar to the previous four samples. Among these samples, the animals identified as totally grass-fed did indeed have the highest cesium–137 levels.

By contrast, it can be seen from part B of the table that the two feedlot samples from the same vicinity (Nos. 7 and 8) had cesium–137 levels of 200 and 140 pCi/kg (54 and 43 pCi/g K), respectively. The range of results from the lower quality samples also contrasts sharply with the combined results from the entire 26 samples from feedlot animals as presented in part C of table 1. These samples had an average cesium–137 concentration of only 240 pCi/kg, and the values ranged from 110 to 540 pCi/kg.

Discussion of results

There is a pronounced difference between cesium–137 levels in USDA Good and USDA Choice meat from feedlot animals and the levels in lower quality meat from animals identified as having been fed on various amounts of grass. Although the magnitude of difference is much greater, the direction of difference is similar to that observed by Ward and Johnson in 1963 (*3*). They found that levels in meat from dairy cows and calves on pasture or hay were about three times as high as those in meat from dairy cows on hay and grain and in meat from feedlot animals.

In a given animal species, the levels of environmentally acquired radionuclides are influenced primarily by the dietary intake of these radionuclides. Among the cattle feeds, forages have been reported to have cesium–137 concentrations that are about an order of magnitude higher than those in grain and other feeds (*3*). This has been observed in the Tampa milkshed (*2*) and in other parts of the State.[5] Hay and forage should then be the primary sources of cesium–137 for animals whose diets include significant amounts of these feeds. A reasonable upper limit for Florida grasses might be taken from the work of Porter et al. (*2*), who reported Tampa pangola grass ranging from 3,700 to 9,600 pCi/kg (dry weight) in 1963–1964.

Ward and Johnson also attributed differences in meat concentrations to differences in the transfer coefficient[6] from diet to meat for this nuclide (*3*). Although unable to separate completely the influence of age, diet composition, and type of animal, they reported transfer coefficients from diet to meat that were higher for beef animals in the feedlot (0.03) than for dairy cows (less than 0.01) and were highest for younger animals (0.04 to 0.1 for 6-month-old calves on pasture).

Either the feed concentration, the transfer from feed to meat, or both, must have been extremely high in the case of several of the animals sampled in this study. The highest radionuclide concentrations observed in meat (on the order of 10,000 pCi/kg) can be predicted for an equilibrium situation by using an extreme cesium–137 concentration in grass of 10,000 pCi/kg and an extreme transfer coefficient of 0.1 and by assuming an intake of 10 kg (dry weight) of grass per day.

Possible sources of high intake, over and above that due to the grass levels quoted, may have been poor pastures where the animals were forced to browse on close-growing plants or plant portions in the litter. Cesium–137 levels have been reported to be much higher in the root mat than in the grass in Midwest grassland; the findings of levels of this nuclide 3 to 50 times higher in caribou than in moose in the same areas of Alaska and Canada have been attributed to the greater utilization of lichen and possible plant litter in the caribou diet (*4, 5*). Higher than expected intakes might

[6] Transfer coefficient = radioactivity concentration per kilogram of meat/daily intake of radioactivity.

also result where animals have access to the epiphyte, Spanish moss (*Tillandsia usneoides*). Investigators in this laboratory and Porter et al. (*2*) have found the cesium–137 levels in this medium to be among the highest in the Florida environment.

The levels of cesium–137 in grass-fed Florida beef were compared with reported concentrations in meat from various selected situations as summarized in table 2. The average of the eight samples from grass-fed animals, 4,000 pCi/kg, is an order of magnitude higher than the average reported by Ward and Johnson (*3*) for pasture animals in 1963 at Fort Collins Colo., and the highest value found is about 36 times their highest reported value. These extreme values are comparable to what has been reported for cattle in Norway and approach those reported for reindeer and caribou in the Arctic (*5–10*). The higher values are also comparable to the average level reported by Plummer for cesium–137 in Georgia deer browsing in the wild (*11*).

It has been estimated that meat and milk contribute about equally as the principal sources of cesium–137 intake for persons who drink Florida milk and whose total meat consumption contains the average levels of cesium–137 found in meat from feedlot beef in peninsular Florida.[5] The data reported here indicate that if the majority of meat consumed had cesium–137 levels equal to the average observed in the low-quality samples analyzed in this study (about 4,000 pCi/kg), this commodity would greatly exceed all other food categories as the source of cesium–137 intake.

In conclusion, levels of cesium–137 in beef from grass-fed animals in Florida appear to be much higher than those in grain-fed animals. Since the former usually produce lower-grade carcasses, intake of this nuclide by humans will vary inversely with the quality of beef consumed. Therefore, one would expect body burdens in humans to be inversely related to the economic status of the family, a relationship suggested previously by Ward and Johnson (*3*).

Table 2. Some recently reported cesium–137 levels in various meats

Investigator	Reference number	Meat-description	Location	Date	pCi/kg		
					N [a]	$\bar{x}$ [b]	R [c]
Roessler:	—	Lean beef (Cutter, canner, utility grades; grass-fed)	North Central Florida	Jan-June 1967	8	3,990	293–12,500
	(d)	Lean beef (Good and choice; feedlot)	Florida-Statewide		33	214	55– 539
	(d)		"Peninsular" Florida		26	240	109– 539
Ward and Johnson:	(3)	Feedlot beef	Ft. Collins, Col.	1963	44	101	
		Dairy cows on hay and grain			9	114	24– 173
		Dairy cows, calves on pasture			11	330	116– 578
Tri-City Study:	(12)	Meat	3 U. S. Cities	1965	—	217	93– 338
Anonymous:	(14)	Meat (home produced and imported)	United Kingdom	1965	—	280	
Madshus:	(6,10)	Beef	Southwest Norway	Late fall, 1964	—	900	300– 2,600
			Southeast Norway		—	2,500	1,600– 4,400
			North Norway		—	2,300	800– 4,100
Hvinden:	(7)	Beef	Norway	1965	—	1,700	
		Reindeer			—	71,000	
Miettinen:	(9)	Reindeer meat	Finnish Lapland	Winter 1960	—	35,300	
				Winter 1961	—	18,000	
				1961	—	—	7,400–18,000
Chandler and Snaveley:	(5)	Caribou meat	Alaska	December 1963	132	13,800	400–57,000
		Reindeer meat		April 1966	152	18,000	2,080–47,000
Anonymous:	(8)	Caribou meat	Alaska	March-May 1967	15	19,000	11,000–31,000
		Reindeer meat			15	24,000	13,000–46,000
Madshus:	(10)	Reindeer	Norway	1964–1965	10	33,500	10,800–51,200
Plummer:	(11)	White-tailed deer in the wild	Georgia	1966	—	9,000	
Brar and Nelson:	(13)	Beef	Chicago	January 1967	—	28	
				April 1967	—	19	
				July 1967	—	46	

[a] N = number of samples, where reported.
[b] $\bar{x}$ = average content.
[c] R = range of reported values.
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Technical Notes

Thermoluminescent Radiation Dosimetry Applied to Dental X-Ray Exposures

John R. Howley, Charles Robbins and *Mardalee B. Dickinson*[1]

For a little more than a decade, dentists in hospitals and clinics have been developing a panoramic radiographic technique which produces a full-mouth radiograph on a single strip of film (figure 1). An excellent summary of this technique is given by Updegrave (*1*). During this x-ray procedure, the patient's head remains stationary while the film and the x-ray source, each mounted on opposite ends of a metal support, rotate around the patient's head (figure 2). At the half cycle, the axis of rotation is changed in order to position each side of the patient's head symmetrically with respect to the film and also to minimize distortion. A special value of panoramic radiography over the conventional, full-mouth, periapical, radiographic survey is that no film is placed in the mouth of the patient so there is no discomfort. This procedure can also be used to show the status of development and eruption of teeth at various ages. Since the procedure uses intensifying screens and increased object-to-film distance, the definition and detail are relatively poor. Consequently, this procedure is limited to those situations where clarity is not essential. Panoramic radiography is not intended to replace conventional periapical radiography, but rather to complement it (*1–3*).

[1] Messrs. Howley and Robbins and Mrs. Dickinson are health physicists with the Radiation Safety Section, Department of Nuclear Medicine, National Institutes of Health, Bethesda, Md. 20014.

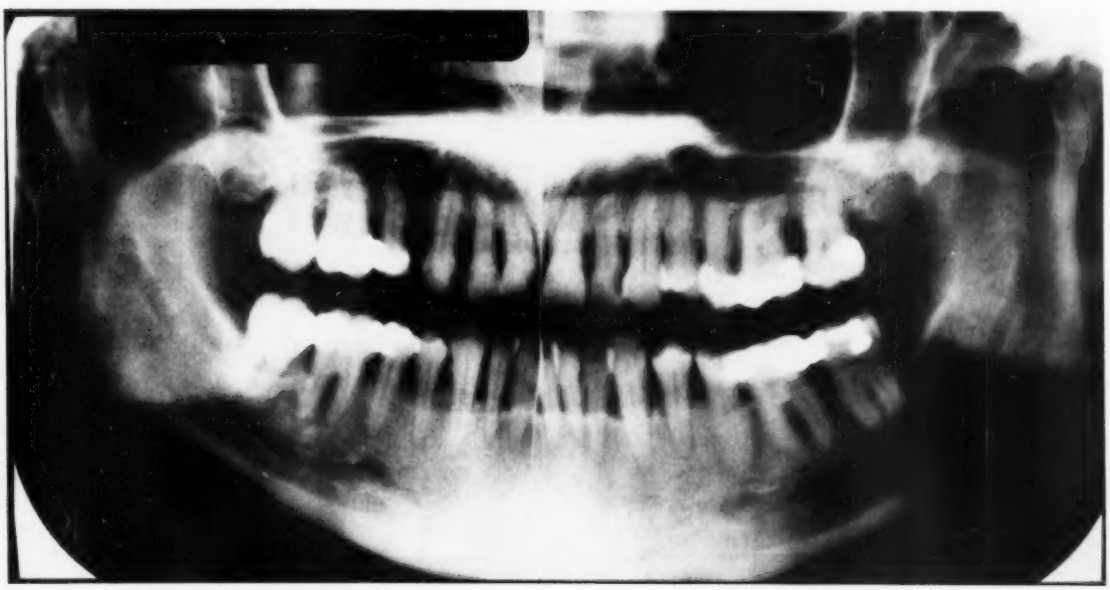

Figure 1. A full mouth x-ray by panoramic technique

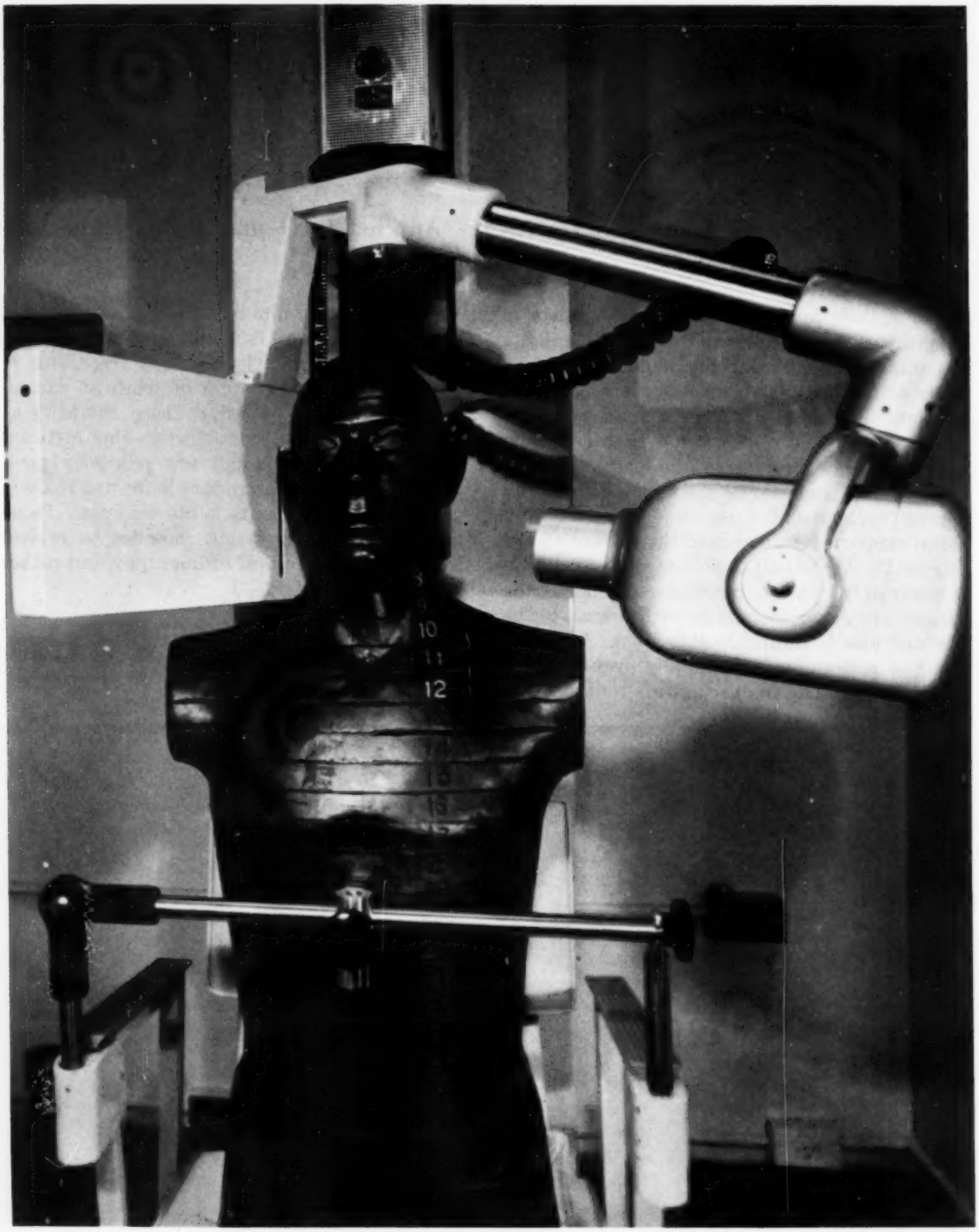

Figure 2. A Rando human phantom and the Panorex dental x-ray unit

Contrasted with the above is the conventional full-mouth x-ray examination which consists of 7 exposures to the upper jaw and 7 exposures to the lower jaw, with dental film placed in the mouth of the patient.

The purpose of this study was to demonstrate the use of thermoluminescent dosimeters in these diagnostic techniques. It was also of interest in making radiation safety surveys to compare the patient radiation exposures from the panoramic technique with the exposure from the conventional technique.

The problem

The rotating narrow x-ray beam used in panoramic dental radiography introduces some complications in the radiation dosimetry measurements (*4*). Dosimetry with film is hampered by energy and directional dependence primarily due to scattered radiation (*5*). Dosimetry by ion chamber techniques is limited by the necessity for uniform irradiation of the entire sensitive volume (*4, 6–8*). The problem of panoramic dosimetry is one of measuring the radiation exposure from a very narrow beam of primary x rays plus scattered radiation.

Method

Miniature glass encapsulated lithium fluoride thermoluminescent dosimeters (TLD), figure 3, placed at selected locations within a Rando human phantom were exposed to radiation from a single film panoramic (Panorex) x-ray procedure and to radiation from a conventional full-mouth dental x-ray procedure, for the purpose of comparison. The panoramic radiographic procedure, as practiced at the National Institutes of Health, involved a 30-second rotational exposure at 10 mA and 80 kVp. The half-value layer of this beam was 1.5 mm of aluminum. The conventional procedure consisted of 14 exposures to selected positions about the jaw at 65 kVp, 10 mA and 0.8 second per exposure. The x-ray tube target-to-skin distance for the conventional unit was 18 inches. The half-value layer of the x-ray beam was 2 mm of aluminum. The diameter of the useful x-ray beam from the conventional unit was approximately 3 inches at the tip of a 16-inch beam collimator,

Figure 3. The glass encapsulated lithium fluoride thermoluminescent dosimeter

in contrast with a 3-inch-long by 0.25 inch wide x-ray beam from the Panorex unit at an x-ray tube target-to-skin distance of 12 inches.

Thermoluminescent dosimeters were chosen for this study because they minimize the problems of energy and volume dependence (*9–11*) which are associated with the other dosimeter types considered. Directional dependence remained a complication. A 25 percent reduction in reading was observed for exposures to the smaller surface of 1.4 x 12 mm dosimeters compared with similar exposures to the larger surface. A major difficulty in low dose dosimetry with TLD in the past has been background interference, principally from electronic noise. Recent improvements in these systems have reduced this difficulty to a minimum. Exposures in the milliroentgen range were measured with a background, including noise, of less than 2 mR. The glass-encapsulated dosimeters were uniform, reasonably rugged and required no prior annealing or nitrogen atmosphere for low exposure measurements. Dosimeters exposed to 50 mR had a standard deviation of 3 percent. Readings at 10 mR had a standard deviation of 20 percent. Solid hot-pressed lithium fluoride dosimeters, a more recent innovation, were also tested and found to be as sensitive as glass-encapsulated dosimeters.

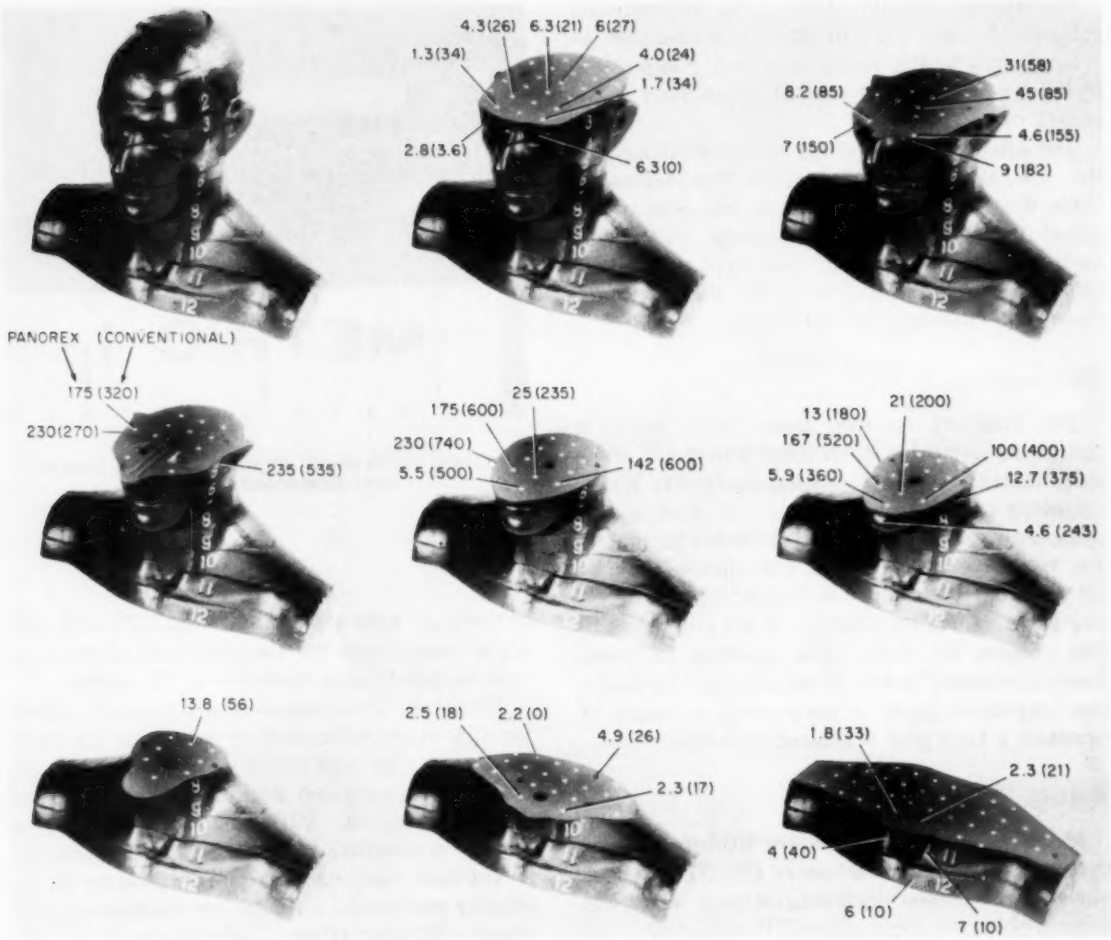

Figure 4. Milliroentgen exposure for a full mouth x-ray procedure with the Panorex vs. a conventional (values in parentheses) technique

Findings

Radiation dosimetry data for patients exposed to panoramic and conventional full-mouth radiographic procedures were obtained by exposing the glass-encapsulated TLD at various locations within a Rando human phantom. In order to obtain a reliable value for a single exposure from the Panorex, it was necessary to calculate this from ten integrated exposures. A comparison of exposures at selected points of interest is illustrated in figure 4, in milliroentgens. Phantom sections 5 and 6 were in the center of the primary x-ray beam, 3 inches long by 0.25 inches wide. The exposure for a single Panorex procedure is shown first, followed by the exposure for a full-mouth, conventional x-ray procedure in parenthesis. The conventional procedure consisted of 14 intraoral films with overlapping fields of exposure.

A Victoreen R meter was used to calibrate the TLD system in the energy range of interest. For this reason the exposure measurements in these experiments are reported in milliroentgens. Factors for the conversion of exposure to absorbed dose are available in NBS Handbook 85.

TLD measurements of surface exposures on the phantom were compared with film dosimeter measurements using the Panorex procedure and are shown in table 1. The TLD was considered to be the more accurate of the two dosimeters because it is less energy dependent than film. Kodak type 3 personal monitoring film was used in the study. TLD and film readings for sections 5 and 6 exposed to the primary beam are consistent. The readings in the other sections are outside the primary beam and are believed less consistent because of the limited accuracy of film as well as TLD in this low exposure range and the variable response of film to the spectrum of scattered radiation energies.

Table 1. Comparison of exposure values for thermoluminescent and film dosimetry for surface exposures of a Rando phantom

Phantom section	Location	TLD (mR)	Film (mR)
3	Right eye	2.8	2.0
4	Right eye	7.3	3.0
5	Right jaw	235	240
6	Right jaw	230	230
7	Right jaw	13.2	20.0
11	Parathyroid	4.0	.9
12	Thyroid	5.6	.6

Summary

The glass-encapsulated thermoluminescent dosimetry system has been found to be an effective method of conveniently measuring radiation exposure from dental and other diagnostic medical x-ray machines. It has been found to overcome some of the important problems associated with the use of small ion chambers and film.

The TLD system was compared with the film dosimetry and the results were consistent except at very low exposures where film suffers from energy dependence in a scattered radiation field.

It is apparent from the phantom measurements obtained that the patient radiation exposure is considerably less from the panoramic radiographic procedure than from the conventional full-mouth series.

Acknowledgment

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Representative products and manufacturers are named for identification only, and listing does not imply endorsement by the Public Health Service and the U.S. Department of Health, Education, and Welfare.

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A Procedure for Evaluating Environmental Radiation Dose to Children in the Vicinity of the Hanford Project in Washington, April 1965–January 1967

John F. Honstead[1]

The Hanford Atomic Energy Commission Installation in southeastern Washington releases small amounts of radioactive materials to the local environment in low-level waste effluents. Radioactive materials enter the Columbia River with reactor cooling water released after a short hold-up period. Once released to the river, this radioactive material enters a number of ecological pathways of varying complexity which may result ultimately in some of the radioactivity reaching human populations living adjacent to the Hanford project. The radiation dose received by populations affected by Hanford operations is evaluated annually (*1*). Part of the dose such people receive is the result of internal deposition of radionuclides obtained from locally produced foodstuffs. The necessary information for estimating such deposition is the concentration of radionuclides in locally-produced foodstuffs, the consumption levels of such foods by local people, and the metabolic behavior of the radionuclides when consumed.

A conventional environmental program such as that followed at Hanford for many years will adequately provide information concerning the average concentration of radionuclides in locally-produced foodstuffs and the distribution of nuclide concentrations about the sample mean (*1*). Likewise, the literature *e.g.*, the ICRP Report of Committee II on Permissible Dose for Internal Radiation (*2*), provides information concerning the uptake and retention of most radionuclides of interest when consumed by man. In the absence of any more definitive information concerning absorption of nuclides from specific foodstuffs these data are utilized in our dose estimates.

[1] Mr. Honstead is manager, Environmental Studies Section, Pacific Northwest Laboratory, Battelle Memorial Institute, Richland, Wash. 99352.

The middle step in this calculation process (the estimation of consumption levels and the population distribution of various consumption levels) is actively being studied by Battelle-Northwest Laboratory. To obtain dietary data for a sample of the adult population, a diet form was prepared which is routinely presented to all people measured in the Hanford whole-body counters. The questionnaire requires a subjective estimate of consumption levels of various significant foodstuffs on the part of the subject. For example, he is asked to estimate "how many glasses of water usually drunk per day." Similar questions are also asked regarding consumption of milk, seafood, game birds, Columbia River fish, and fresh meat. Supporting information concerning sources of such foodstuffs is obtained to help identify the size of the population routinely consuming certain kinds of foods from local sources. An initial report of this investigation was recently issued (*3*).

The Hanford whole-body counter is used routinely as a monitoring tool in the plant; thus, the vast majority of the people measured are plant employees. These employees are assumed to be a representative sample of the local adult population but they obviously cannot be representative of the entire population. The major population group missing from this survey is children living near the Hanford facilities. The dietary habits of children are vastly different from those of adults and cannot really be derived from adult data. To study the children's dietary levels we have initiated an investigation in cooperation with the local school system. This paper describes the program that was developed and presents some of the results obtained to date.

Description of the procedure

In establishing a research procedure to investigate diets and radionuclide body burdens in local children we had to provide motivation for the schools to cooperate with us, for the parents to give permission for their children's participation, and for the children to take part in the study. A serious attempt was made to inform the children about radioactivity and radiation along with the introduction of the program. Questions that arose were answered frankly and information concerning the measurements and the results were made available to anyone interested. More than 80 percent of the 1,800 school children in the eight elementary schools (grades 1–6) so far approached participated in this study.

Questions requiring evaluation by the child of the amounts of various foodstuffs consumed cannot reliably determine consumption levels for children. Instead the child is asked to keep a record of the pertinent foodstuffs eaten and drunk during a consecutive 7-day period. This record is maintained by recording each helping or cup of foodstuff consumed. Some diet records, perhaps between 1 and 2 percent, were discarded because the child obviously did not understand what was required.

About 2 weeks after the classroom discussion the Hanford mobile whole-body counter was moved to the school and parked in a convenient location on the schoolground. The counter uses a shadow shield and incorporates an 11-inch sodium iodide crystal (*4, 5*). It requires about 1 month to count the children in one elementary school. Each child is counted for 10 minutes in the shadow shield counter and about 2 minutes are required for printing and recording the data. Thus, it is possible to measure 25 to 30 children each day. Each child is absent from class about 30 minutes.

Diet study results

The data obtained from diet record forms are reduced to punch cards for use in an electronic computer system and will ultimately be entered on a magnetic tape file. To date a little over 1,500 such records have been analyzed and more than twice that number have been collected from school children. Some of the consumption level distributions assembled by electronic data processing techniques are shown in figures 1 through 4.

Figure 1 shows the water consumption reported by children. Older children averaged slightly higher water consumption than the younger children, although the difference is probably not significant. When adults estimated their own water consumption levels they reflected a significant bias for even numbers and multiples of 5. The children's results, being a tabulation of actual consumption observations, do not have this kind of bias.

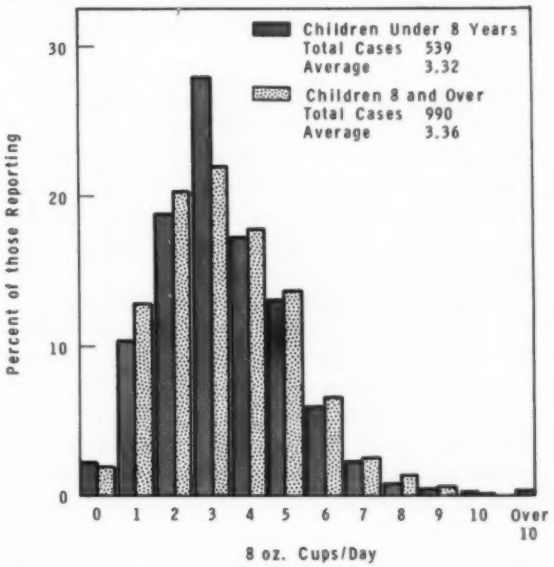

Figure 1. Water consumption during a 7-day recording period

Figure 2 shows milk consumption as reported by children. The children averaged about 2.7 cups of milk per day compared to an adult average of 1.7 cups per day.

Figure 3 shows the children's estimates of their seafood consumption. The study attempted to obtain estimates of the number of times per year that they ate seafood produced along the Washington coast, such as fresh oysters, fresh clams and fresh crab meat. This chart does not represent actual consumption data but the children's estimates of their annual consumption levels. The bias introduced by human preference for certain numbers can be noted. The children estimated an average consumption

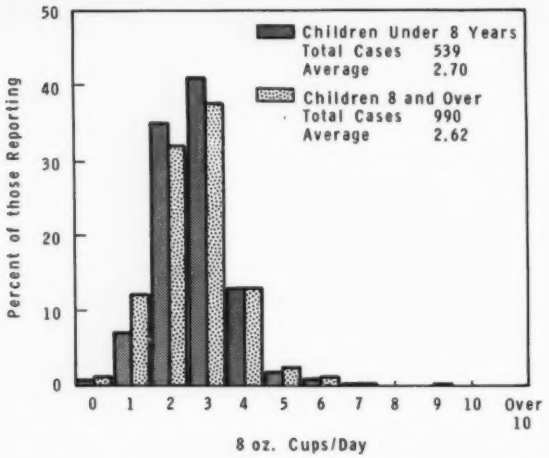

Figure 2. Milk consumption reported by elementary school children

of local seafood of about 2.8 meals per year compared to the adult estimate of 6 meals per year. Over 60 percent of the children reported never eating local seafood compared to only 35 percent of adults.

In figure 4 the consumption level distribution for fish caught in the Columbia River below the Hanford plant is shown. Children under 8 report an average of 2.4 meals per year while the older children report an average of 2.7 meals per year. This probably reflects a mistaken interpretation of the question on the part of the children. They probably are including all fish consumption, in some cases, rather than limiting it to Columbia River fish. Adults, when asked the same question, estimated 1.9 meals per year. Seventy-five percent of the adults indicated that they never eat Columbia River fish.

Whole-body counter measurements

None of the more than 3,000 children measured in the mobile whole-body counter to date have had body burdens of radionuclides outside of the range anticipated on the basis of known environmental conditions. Typical values of radionuclide burdens measured in children were 3 to 5 nCi of each of the radionuclides, zinc–65, sodium–24 and cesium–137. Body burdens ranging up to several times the typical values were occasionally detected where unusual circumstances resulted in diet sources more directly related to the Columbia River. These ranges agree with those that would be predicted from our knowledge of the environmental concentration levels. The quantitative measurement of radionuclides in children depends on the construction of a suitable calibration function for the shadow shield counter. It cannot be assumed that the calibration factors derived for standard man are applicable to children's measurements. A calibration study was conducted concurrently with the measurement of children. In the absence of a definition

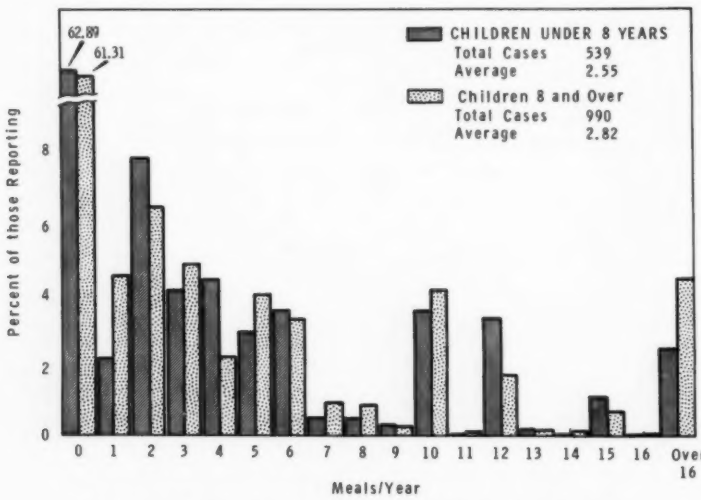

Figure 3. Consumption levels for locally produced seafood

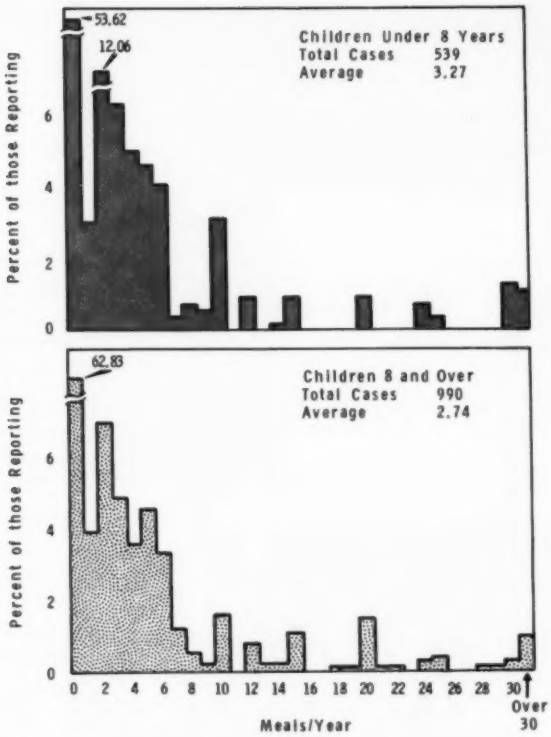

Figure 4. Columbia River fish consumption reported by Richland school children

for a standard child we developed an array of 9 phantoms for children ranging in size from 48 to 107 pounds. The phantoms are constructed of 1-pound boxes of sugar as shown in figure 5. A phantom containing no added radioactivity is first constructed on the bed of the counter and measured to provide background data. Then a phantom using sugar boxes containing known amounts of radionuclides is constructed in an identical way and measured with the counter. After subtracting background readings the measurements may be used to calculate a calibration factor for the radionuclides and phantom size used. In this way, calibration factors for each of the 9 phantoms for zinc–65, potassium–40, cesium–137, and sodium–24 were derived.

These data were used to construct an empirical function relating body size to calibration factor which can be programmed for the computer to provide absolute body burden measurements. Linear, exponential and power functions were examined for these data. The goodness of fit of functions obtained with a parameter of pounds weight per inch of height as compared to functions involving simply pounds was also evaluated. A linear correlation technique was used for selecting the best fit for each of these functions. The calibration curves that best fit the data were exponential functions calculated in this way and the calibration points from which the functions were derived. It would be most helpful if some calibration data from children were available to confirm these calibration functions.

Application of the procedure

Environmental dose estimates for the population living adjacent to the Hanford plant include the dose to a typical resident and to a special population group having diet habits that maximize exposure. The procedure described for obtaining data from school children will assist with the identification and study of the affected population

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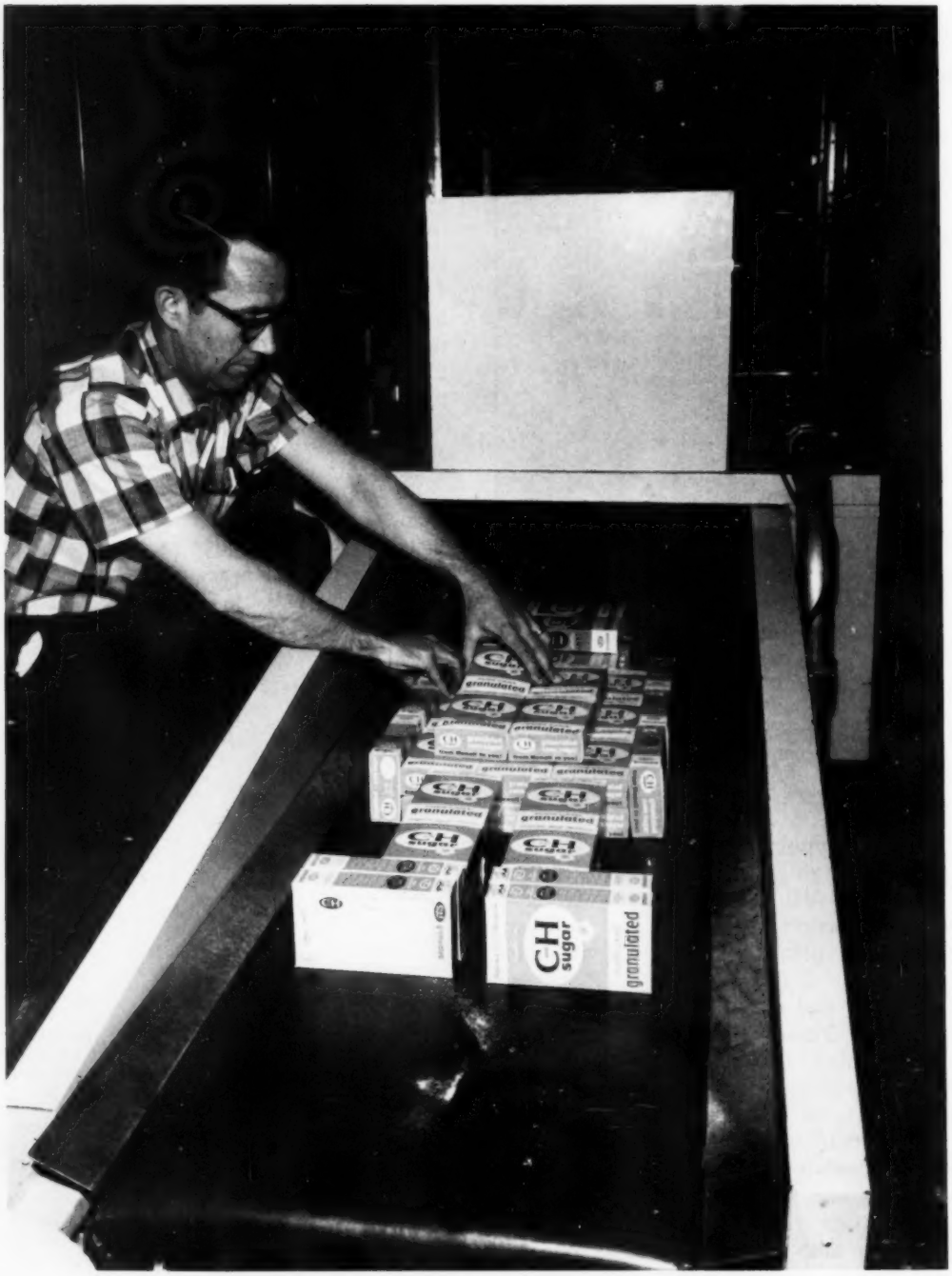

Figure 5. Shadow-shield whole body counter with phantom in place

Gamma-Emitting Fallout in Surface Air at Fort Collins, Colo., 1962–1967[1]

Daniel W. Wilson and *Gerald M. Ward*[2]

Surface air gamma-ray activities of the fission products cerium–144, antimony–125, ruthenium–106, cesium–137 and a neutron activation product, manganese–54, all from nuclear weapons testing, were measured at Fort Collins, Colo. from 1962 to 1967. These measurements were part of a study of the transport of worldwide fallout from the atmosphere to milk. Of these radionuclides, only cesium–137 has been observed regularly in milk (*1*), but there has been some evidence of manganese–54 in milk (*2*). All of these radionuclides (with the addition of zirconium-niobium–95) have been identified in air, precipitation and forages, and cerium–144, cesium–137 and manganese–54 have been identified in animal tissue (*2*). In periods immediately following nuclear weapons tests, iodine–131 and barium-lanthanum–140 were observed in forage and milk (*3*).

In our studies, air levels of cesium–137 have been found to be a reliable indication of forage and milk contamination, and we believe that the importance of direct deposition from air to vegetation (dry deposition) has been underestimated previously in food chain transport models (*4*). Measurements of radionuclides other than cesium–137 are valuable because the data provide a means of interpreting the atmospheric behavior of fallout.

Analytical methods

Sampling was performed by drawing air through particulate (BM–40) filter pads using a high volume sampler with a flow rate of one SCM per minute. The sampler was located 1.5 meters above ground in a louvered box used to exclude rain. Air was sampled each day from noon to 4 p.m. The volume flow rate of the sampler was read with a calibrated meter at the beginning and end of each sampling period. Pads were usually collected for gamma-ray analysis on a weekly basis, but daily during the summer months of high fallout.

Counting was carried out by gamma-ray scintillation spectrometry with a 4- by 8-inch NaI (Tl) crystal and a multichannel pulse height analyzer. Determination of activity of each radionuclide was accomplished by computerized spectrum stripping of interference from the photopeak areas. The same computer program corrected for radioactive decay from day of counting to the day of sampling. Cesium–137, with a long radioactive half-life, was redetermined after a time lapse sufficient to allow interfering radioactivity to decay to an insignificant amount. It is expected that for this reason cesium–137 measurements are the most reliable of the nuclides reported.

Results and discussion

Monthly means for each fission product were characterized by rather high standard deviations, but the time trends for all radionuclides were generally similar (table 1 and figure 1). High standard deviations are attributed to actual fluctuations in surface air activities during a month rather than to experimental errors, as monthly mean values compare well with other data published for the same time period (*5, 6*). Peak values for all radionuclide activities in air during the 5-year time span occurred in the spring of 1963, and levels decreased approximately exponentially from that time. The exponential decrease was modified by two factors, a "spring maximum" each year, and by increases in activities in 1966 following foreign atmospheric nuclear tests.

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[1] Supported by AEC Contract (11–1)–1171 and published as COO 1171–79.

[2] Dr. Wilson and Dr. Ward are from the Department of Animal Science, Colorado State University, Fort Collins, Colo. 80521.

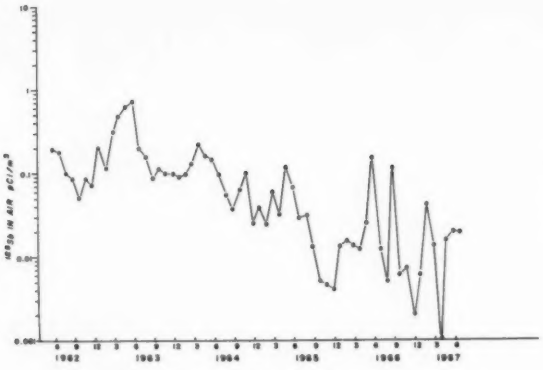

Figure 1. Gamma emitting fallout radionuclide in surface air (antimony–125)

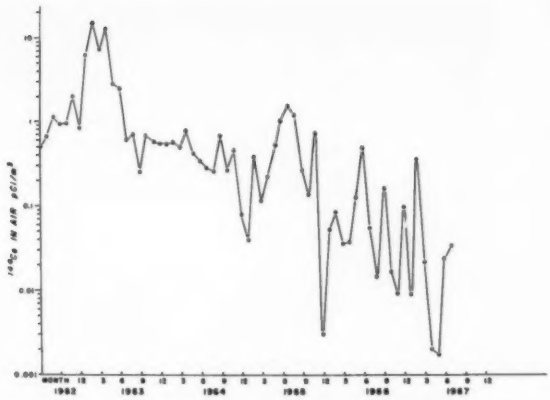

Figure 1. Gamma emitting fallout radionuclide in surface air—Continued (cerium–144)

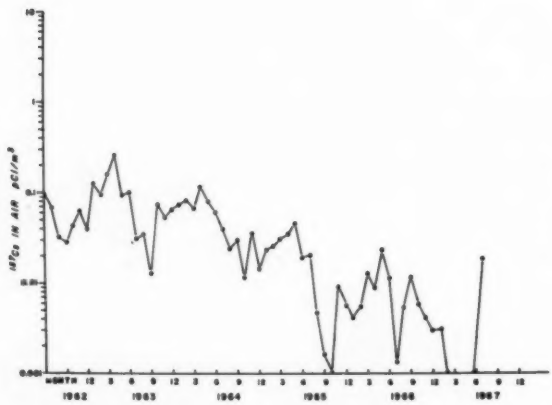

Figure 1. Gamma emitting fallout radionuclide in surface air—Continued (cesium–137)

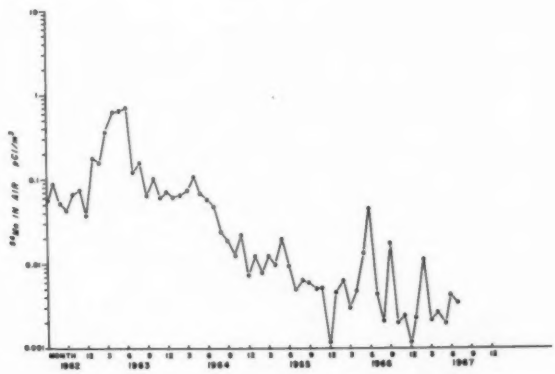

Figure 1. Gamma emitting fallout radionuclide in surface air—Continued (manganese–54)

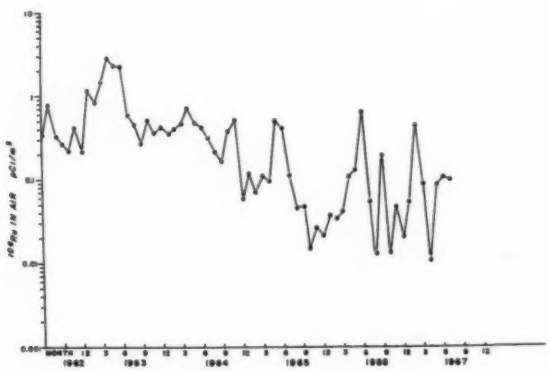

Figure 1. Gamma emitting fallout radionuclide in surface air—Continued (ruthenium–106)

Table 1. Antimony–125 in surface air at Fort Collins, Colo.
(pCi/m³)

Month	1962		1963		1964		1965		1966		1967	
	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
January			0.198	0.352 (9)	0.087	0.043 (6)	0.038	0.019 (3)	0.014	0.009 (2)	0.006	0.006 (4)
February			.114	.082(12)	.094	.032 (5)	.023	.019 (4)	.015	.010 (8)	.041	.055 (2)
March			.295	.183(10)	.126	.016 (5)	.056	.024 (2)	.013	.006 (8)	.014	(1)
April			.466	.364 (6)	.209	(1)	.030	.014 (2)	.013	.009 (7)	.001	(1)
May			.597	.422 (8)	.149	.091 (6)	.110	.109 (3)	.024	.023(12)	.015	(1)
June	0.197	0.174 (2) [a]	.696	.458 (6)	.143	.057(22)	.063	.080 (3)	.137	.379(13)	.019	.022(10)
July	.175	.061(13)	.189	.120 (7)	.089	.065(22)	.028	.021 (7)	.012	.010 (7)	.019	.005(10)
August	.100	.034(17)	.153	(1)	.053	.034(10)	.030	.018 (5)	.006	.004(10)		
September	.085	.029(11)	.083	.017 (4)	.035	.008 (3)	.013	(2)	.106	.276 (8)		
October	.051	.036 (9)	.114	(1)	.061	.049 (3)	.005	(1)	.006	.006 (9)		
November	.086	.038 (8)	.095	.030 (4)	.092	.049 (5)	.005	(1)	.008	.005 (4)		
December	.072	.033 (3)	.094	.003 (4)	.024	.016 (4)	.005	(1)	.002	(1)		

[a] Parentheses give number of samples.

Table 1. Cerium–144 in surface air at Fort Collins, Colo.
(pCi/m³)

Month	1962		1963		1964		1965		1966		1967	
	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
January			6.02	7.38 (9)	0.531	0.273 (6)	0.038	(1)	0.049	0.052 (2)	0.010	0.010 (4)
February			13.9	10.3 (12)	.555	.096 (5)	.364	0.315 (3)	.083	.056 (7)	.335	(1)
March			7.02	4.87 (10)	.482	.017 (5)	.111	.062 (2)	.035	.038 (8)	.021	(1)
April			13.0	6.79 (6)	.756	(1)	.203	.124 (2)	.037	.025 (6)	.002	(1)
May			2.75	1.96 (8)	.405	.146 (6)	.501	.452 (3)	.123	.166 (8)	.002	(1)
June	0.495	0.603 (2) [a]	2.41	1.57 (6)	.351	.198(22)	.971	(1)	.518	1.33 (13)	.024	.029 (7)
July	.683	.407(10)	.599	.486 (7)	.278	.239(21)	1.44	.970(14)	.053	.019 (4)	.037	.027(10)
August	1.12	1.50 (14)	.694	(1)	.245	.166 (9)	1.15	.758 (9)	.014	.009(10)		
September	.931	1.10 (10)	.244	.144 (4)	.645	.486 (3)	.252	.045 (2)	.155	.399(13)		
October	.945	.266 (9)	.668	(1)	.254	.323 (3)	.133	.066 (2)	.016	.017 (7)		
November	1.99	.828 (8)	.551	.134 (4)	.481	.488 (5)	.680	(1)	.009	.007 (4)		
December	.829	.353 (3)	.534	.098 (4)	.078	.044 (4)	.003	(1)	.094	(1)		

[a] Parentheses give number of samples.

Table 1. Cesium–137 in surface air at Fort Collins, Colo.
(pCi/m³)

Month	1962		1963		1964		1965		1966		1967	
	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
January			0.124	0.208 (9)	0.070	0.038 (6)	0.022	0.002 (3)	0.004	0.001 (2)	0.003	0.004 (2)
February			.092	.043(11)	.079	.016 (5)	.025	.007 (4)	.005	.004 (8)	.001	.001 (2)
March			.155	.086(10)	.065	.016 (5)	.029	.002 (2)	.012	.005 (8)	.000	(1)
April			.255	.206 (6)	.113	(1)	.034	.015 (2)	.009	.006 (7)	.000	(1)
May			.094	.061 (8)	.076	.036 (6)	.044	.027 (3)	.023	.030(11)	.000	(1)
June	0.096	(1) [a]	.098	.033 (4)	.060	.029(23)	.019	.019 (4)	.011	.012 (7)	.001	.002 (4)
July	.068	.045(13)	.031	.019 (7)	.039	.043(19)	.019	.020 (7)	.001	.002 (4)	.018	.026 (2)
August	.032	.016(17)	.033	(1)	.023	.019(10)	.005	.005 (4)	.005	.004 (5)		
September	.028	.019(11)	.013	.004 (4)	.028	.012 (3)	.002	.002 (2)	.011	.010(11)		
October	.042	.013 (9)	.071	(1)	.011	.001 (2)	.001	(1)	.006	.007 (6)		
November	.063	.029 (8)	.051	.011 (4)	.034	.050 (3)	.009	(1)	.004	.003 (3)		
December	.039	.012 (3)	.065	.005 (4)	.014	.010 (4)	.006	(1)	.003	(1)		

[a] Parentheses give number of samples.

Table 1. Manganese–54 in surface air at Fort Collins, Colo. (pCi/m³)

Month	1962		1963		1964		1965		1966		1967	
	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
January			0.173	0.266 (8)	0.060	0.036 (6)	0.012	0.005 (3)	0.005	0.004 (2)	0.002	0.002 (4)
February			.154	.084 (9)	.063	.011 (5)	.008	.006 (4)	.006	.004 (7)	.011	.014 (2)
March			.356	.183(10)	.071	.006 (5)	.012	.005 (2)	.003	.003 (8)	.002	(1)
April			.614	.528 (6)	.104	(1)	.010	.001 (2)	.005	.004 (6)	.003	(1)
May			.630	.483 (8)	.067	.034 (6)	.019	.014 (4)	.013	.016(10)	.002	(1)
June	0.056	0.045 (2)[a]	.683	.392 (6)	.056	.021(22)	.009	.005 (3)	.043	.124(13)	.004	.006 (7)
July	.088	.049(13)	.120	.110 (7)	.047	.060(21)	.005	.005 (2)	.004	.004 (6)	.003	.003 (9)
August	.051	.028(16)	.143	(1)	.023	.011(10)	.006	.008 (5)	.002	.002 (7)		
September	.043	.026(11)	.063	.005 (4)	.018	.003 (3)	.005	.005 (2)	.017	.055(13)		
October	.067	.027 (9)	.098	(1)	.012	.013 (3)	.005	(1)	.002	.002 (9)		
November	.073	.041 (7)	.059	.027 (4)	.022	.013 (5)	.005	(1)	.002	.002 (4)		
December	.038	.022 (3)	.069	.005 (4)	.007	.004 (3)	.001	(1)	.001	(1)		

[a] Parentheses give number of samples.

Table 1. Ruthenium–106 in surface air at Fort Collins, Colo. (pCi/m³)

Month	1962		1963		1964		1965		1966		1967	
	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
January			1.10	1.63 (9)	0.343	0.189 (6)	0.113	0.050 (3)	0.035	0.024 (2)	0.051	0.042 (4)
February			.808	.497 (9)	.381	.073 (5)	.067	.059 (4)	.033	.018 (8)	.406	.562 (2)
March			1.42	.903(10)	.442	.027 (5)	.104	.014 (2)	.039	.009 (8)	.082	(1)
April			2.74	1.91 (6)	.678	(1)	.091	.050 (2)	.102	.200 (7)	.010	(1)
May			2.23	1.61 (8)	.441	.199 (6)	.458	.654 (4)	.122	.194(11)	.082	(1)
June	0.337	0.266 (2)[a]	2.18	1.10 (6)	.394	.175(22)	.381	.325 (4)	.580	1.04 (13)	.100	.060(10)
July	.774	.502(13)	.563	.363 (7)	.293	.296(23)	.107	.064(12)	.052	.062 (7)	.092	.039(10)
August	.324	.211(16)	.439	(1)	.203	.083(10)	.044	.026 (8)	.012	.008(11)		
September	.261	.078 (9)	.261	.056 (4)	.159	.045 (3)	.046	.029 (2)	.181	.560(11)		
October	.214	.151 (9)	.482	(1)	.355	.474 (3)	.014	(1)	.013	.011 (9)		
November	.434	.294 (7)	.327	.064 (4)	.483	.244 (5)	.025	(1)	.045	.046 (4)		
December	.211	.151 (3)	.401	.054 (4)	.055	.055 (4)	.020	(1)	.020	(1)		

[a] Parentheses give number of samples.

The spring maximum effect, which is connected to a periodicity in the stratospheric tapping rate (*7*), was most pronounced for cesium–137, as was also observed by Gustafson (*6*). Damping of the spring maximum effect for the shorter-lived radionuclides may have been due in part to the more rapid losses due to radioactive decay. There was also a difference between the apparent stratospheric residence times for cesium–137 and the shorter-lived nuclides. Stratospheric residence time was estimated by the least squares fit of radionuclide levels verses time according to the equation $A = A_o e^{-\lambda_o t}$, where λ_o, the observed decay rate, represents the sum of $\lambda_a + \lambda_r$, the atmospheric and radioactive decay rates, respectively. Correction for radioactive decay back to the time of the last major atmospheric tests in 1962 and treatment of these data by log-linear regression analysis led to anomalous stratospheric residence times for the short-lived radionuclides (table 2). In this procedure, the slope of the regression line represents the hypothetical rate constant for stratospheric tapping. It is evident that the behavior is more complex than indicated by this procedure, probably due to large direct contributions of the 1962 atmospheric tests to tropospheric levels and to the more recent fallout following the foreign atmospheric nuclear tests.

Table 2. Atmospheric residence times of fallout radionuclides

Radionuclide	Observed Half-time [a] and Standard deviation (days)	Radioactive Half-time [a] (days)	Atmospheric Half-time [b] (days)
Cerium-144	250 ± 50	285	2,300
Antimony-125	400 ± 70	760	680
Ruthenium-106	380 ± 65	365	7,100 (increasing)
Cesium-137	400 ± 60	~11,000	410
Manganese-54	300 ± 40	312	2,000

[a] Half-times derived from statistically best fit of each set of data to the function: $A = A_o e^{-\lambda_o t}$, where λ_o, the observed decay rate, represents the sum of $\lambda_a + \lambda_r$, the atmospheric and radioactive decay rates, respectively.
[b] Calculated as described.

The well-defined behavior of cesium–137 in tropospheric air provides a basis for using air activities as a parameter in considerations of the fallout rate to the biosphere. Monthly cesium–137 activities were analyzed into two components, one describing the buildup of surface air levels which occurred each year to a spring peak, and another describing the decrease of air levels through the spring and summer. The mean half-time for the buildup was 80 days, while the mean exponential half-time for depletion during the summer was 45 days. The 5-year decline in surface air levels, indicated by a line drawn through the annual peak values (figure 2), occurred with a 300-day half-time. This latter component describes the stratospheric residence half-time of cesium–137. While the mechanisms of atmospheric transport of fallout are complex, these data indicate that surface air levels from worldwide fallout are characterized by well defined patterns. This behavior will be useful for prediction of fallout in surface air and subsequent biospheric contamination in the event of further nuclear releases in the atmosphere.

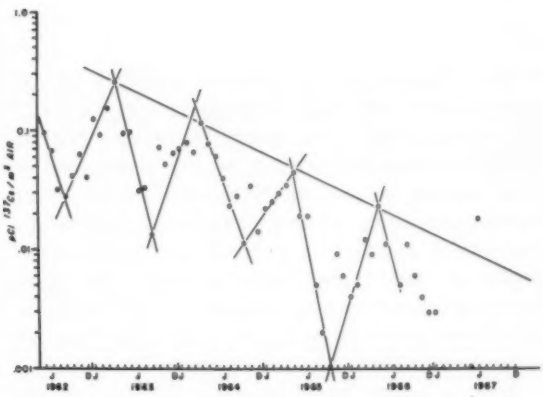

Figure 2. Analysis of cesium–137 in surface air

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Cesium–137 in Milk From the Colorado State University Dairy Herd, 1962–1967[1]

Anthony F. Gallegos and *Gerald M. Ward*[2]

The University dairy herd consists of approximately 125 high milk-producing cows of four breeds, but principally Holstein. The results for transfer of cesium–137 from feed to milk should be applicable to commercial dairy farm operations. Feed and fallout intake along with milk production records and cesium–137 levels of milk were available from this large herd and were used to compare to the relationships developed from closely controlled feeding experiments with smaller numbers of cows (1).

Milk samples were obtained throughout the year from the composite milk output of the entire herd by sampling the bulk storage tank at the dairy farm. Milk from small sub-herds of ten to twenty cows which are grazing on pasture or fed green-cut alfalfa was available during summer months. Bulk milk samples contained milk from these sub-herds at times, but the volume of milk from the latter sources was not sufficient to significantly influence cesium–137 levels in the pooled milk. The main dairy herd was dry-lot fed the year-round. Feed consisted of stored alfalfa hay (principally the third cutting), mixed grain and corn silage. The feeding program is fairly typical of Colorado or western dairy herds.

Analysis for cesium–137 and potassium–40 was done by counting 5.4 liters in a Marinelli-type beaker placed on a 4- by 8-inch NaI (Tl) crystal. Details in milk analysis have been described previously (*2*).

Results

The concentration of cesium–137 in milk (pCi/liter) increased through 1962 and reached a peak in the summer of 1963. Data plotted in figure 1 and tabulated in table 1 consists of monthly means with standard deviations. Samples were collected more frequently in the summer months because more variability was expected. Standard deviations were a small percent of the means in the first and last quarter of the years (winter feeding period), but variability increased each summer. This was due to numerous changes in hay during the summer. Third-cutting hay was largely fed in the winter but the supply generally ran out in June or July. Thus between that time and the time when another supply of third-cutting hay was available, first or second cutting was fed. We have shown large differences in the cesium–137 content of hay for the three cuttings (*3*). The variation in milk from cows on pasture or fed green-cut alfalfa corresponded generally with seasonal trends in the direct fallout rate. This relation, however, was obscured at times by feeding supplemental hay which contained more cesium–137 than the fresh forage being consumed. Thus direct comparisons cannot be made between air or rainfall samples and milk. That these variations were not due to analytical variation is supported by the observation that no such trends were observed in the potassium content of milk (*4*). Potassium and cesium–137 were determined on the same samples and by the same method; gamma-ray spectrometry.

The relationship between the bulk tank levels of cesium–137 versus day collected for the period after the peak gave a linear regression coefficient equivalent to a half-time of 467 days (S.D. ± 22). This is similar to the half-time found for cesium–137 activity in air, which was 400 days (S.D. ± 59). Both cesium–137 in air and milk show periodic deviations from their respective regression lines. For air, this is related to the spring maximum effect, but for milk it is related to feeding practices which may change at any time within the year.

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[2] Mr. Gallegos and Dr. Ward are with the Department of Animal Science, Colorado State University, Fort Collins, Colo. 80521

Table 1. Bulk and pasture milk, cesium–137 monthly averages (pCi/liter)

Month	Type	1962		1963		1964	
		Mean	S. D.	Mean	S. D.	Mean	S. D.
January	Pasture						
	Bulk			30.4	2.0 (6)	82.5	11.3 (4)
February	Pasture						
	Bulk			30.5	2.1 (5)	85.9	3.6 (4)
March	Pasture						
	Bulk			29.6	6.3 (5)	93.8	6.8 (4)
April	Pasture	20.0	(1) [a]				
	Bulk			35.9	3.9 (9)	76.7	2.3 (3)
May	Pasture	63.8	36.7(18)	59.9	33.5(18)	57.9	19.3(14)
	Bulk	13.9	12.8 (6)	31.9	5.0(11)	79.0	26.9 (2)
June	Pasture	75.1	18.4(18)	158.3	29.6(15)	136.9	42.3(21)
	Bulk	28.1	23.3(13)	48.9	17.5(12)	77.2	15.5 (6)
July	Pasture	103.6	50.9(15)	112.8	22.7(13)	74.3	22.1(19)
	Bulk	60.4	24.8(14)	71.4	16.0(10)	101.4	7.1 (2)
August	Pasture	62.0	13.8(20)	118.2	19.7(11)		
	Bulk	39.2	21.9(16)	103.1	19.0(11)	105.2	1.2 (2)
September	Pasture	67.8	18.8(11)	101.2	16.1(20)		
	Bulk	41.5	34.3(10)	138.5	23.4 (5)	63.9	2.2 (2)
October	Pasture	36.5	8.3 (8)	85.6	— (1)		
	Bulk	28.9	6.9 (8)	95.9	4.0 (5)	63.7	6.2 (2)
November	Pasture	33.1	13.4 (4)				
	Bulk	28.0	10.7 (4)	96.4	9.5 (5)	54.0	1.68 (4)
December	Pasture						
	Bulk	30.1	2.6 (4)	107.4	23.5 (3)	52.2	3.03 (3)

Month	Type	1965		1966		1967	
		Mean	S. D.	Mean	S. D.	Mean	S. D.
January	Pasture						
	Bulk	51.3	3.1 (5)	40.1	1.4 (6)	25.9	22.6 (2)
February	Pasture						
	Bulk	64.1	9.7 (5)	38.2	1.1 (6)	13.5	1.0 (2)
March	Pasture						
	Bulk	70.3	5.4 (4)	34.5	3.5 (7)	21.6	(1)
April	Pasture						
	Bulk	55.9	9.3 (5)	33.4	2.1 (8)		
May	Pasture	88.4	23.9(10)				
	Bulk	54.2	4.7 (4)	31.9	2.1 (6)		
June	Pasture	77.6	9.4(30)				
	Bulk	59.8	3.3 (2)	34.1	4.7 (3)	15.5	2.0 (3)
July	Pasture	61.9	26.5(27)				
	Bulk	21.3	5.3 (2)	29.1	3.2 (7)	15.7	3.6 (5)
August	Pasture	18.2	9.1(16)				
	Bulk	18.1	7.2 (2)	29.0	5.2(18)	15.3	4.0 (7)
September	Pasture						
	Bulk	43.0	2.0 (4)	29.2	1.0 (2)		
October	Pasture						
	Bulk	35.9	6.1 (3)	14.2	1.0 (2)		
November	Pasture						
	Bulk	38.2	1.2 (2)	19.4	4.1 (5)		
December	Pasture						
	Bulk	32.9	6.5 (4)	19.8	1.0 (2)		

[a] Numbers in parentheses indicate the number of samples.

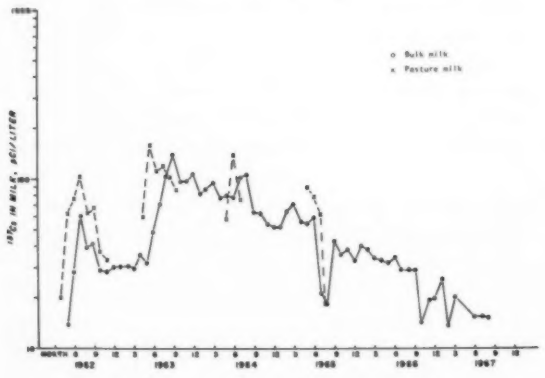

Figure 1. Cesium–137 in milk

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(*2*) WARD, G. M., J. E. JOHNSON, and D. W. WILSON. Determination of Fallout Radionuclides in Environmental Samples by Gamma-ray Spectrometry. Proceedings International Symposium Radioisotope Measurement Techniques in Medicine and Biology, IAEA, Vienna (1965) pp. 33–43.

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Data

SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Federal and State agencies are involved in efforts to monitor continuously the dietary intake of radionuclides. The most direct measure of radionuclide intake would be obtained through radioanalysis of the total diet. Difficulties in obtaining specific dietary data impede this approach. An alternate method entails the use of indicator foods to arrive at an estimate of the total dietary radionuclide intake.

Fresh milk is one such indicator food. It is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides which appear in the diet. It also is one of the major sources of dietary intake for the short-lived radionuclides. For these reasons, fresh milk is the single food item most often used in estimating the intake of selected radionuclides by the general population and/or specific population groups. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of fresh milk.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5, 6*).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

REFERENCES

(*1*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).

(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action for strontium–89, strontium–90, and cesium–137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).

(*5*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 2. Pergamon Press, New York, N.Y. (1959).

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National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in milk.

1. Pasteurized Milk Network April 1968

National Center for Radiological Health and *National Center for Urban and Industrial Health, PHS*

The Public Health Service's Pasteurized Milk Network (PMN) is designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 stations (figure 1) provides data on milk in every State, Washington, D.C., the Canal Zone, and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the January 1968 issue of *Radiological Health Data and Reports* (*1*). Reference should also be made to the February 1968 issue (*2*), in which several changes in the interpretation and reporting of data were introduced.

Table 1. Analytical errors associated with determinations of radionuclide concentrations in a milk sample

Nuclide	Concentration (pCi/liter)	Error [a] (pCi/liter)	Concentration (pCi/liter)	Error [a] (percent of concentration)
Strontium-89	<50	5	≥50	10
Strontium-90	<20	2	≥20	10
Iodine-131	<100	10	≥100	10
Cesium-137	<100	10	≥100	10
Barium-140	<100	10	≥100	10

[a] Two standard deviations.

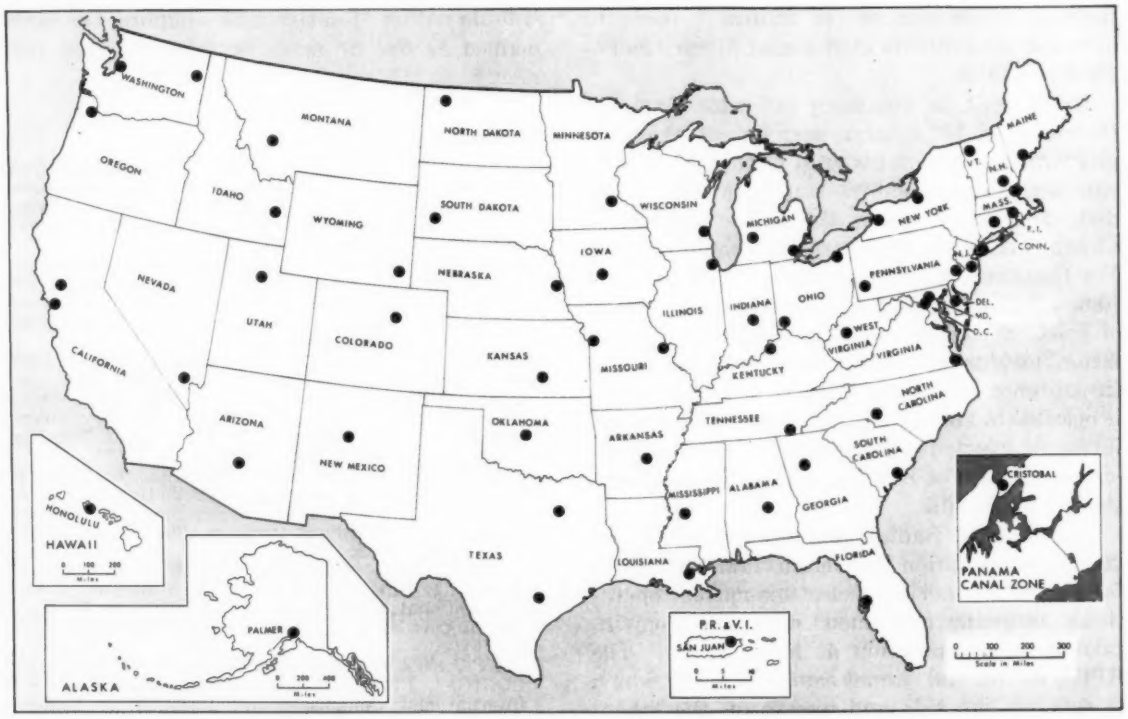

Figure 1. Pasteurized Milk Network sampling stations

Table 2. Average concentrations of radionuclides in pasteurized milk for April 1968 and the 12-month period, May 1967 through April 1968 [a]

Sample location		Radionuclide concentration (pCi/liter)									
		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		May 1967–April 1968	April 1968	May 1967–April 1968	April 1968	May 1967–April 1968	April 1968	May 1967–April 1968	April 1968	May 1967–April 1968	April 1968
Ala:	Montgomery	0	0	9	8	0	0	13	9	0	0
Alaska:	Palmer	0	0	6	5	0	0	17	13	1	0
Ariz:	Phoenix	0	0	1	4	0	0	2	0	0	0
Ark:	Little Rock	0	0	21	18	0	0	19	19	0	0
Calif:	Sacramento	1	0	3	3	0	0	6	8	1	0
	San Francisco	1	0	3	5	0	0	3	2	1	0
C. Z:	Cristobal	0	0	2	0	0	0	14	3	0	0
Colo:	Denver	1	NA	5	0	1	0	7	7	0	0
Conn:	Hartford	NA	NA	9	10	0	0	14	5	0	0
Del:	Wilmington	NA	NA	11	11	0	0	9	4	0	0
D. C:	Washington	0	0	10	10	0	0	6	1	0	0
Fla:	Tampa	0	0	8	6	0	0	71	61	0	0
Ga:	Atlanta	0	0	15	17	0	0	22	19	0	0
Hawaii:	Honolulu	0	0	3	4	1	0	5	8	0	0
Idaho:	Idaho Falls	1	0	6	5	0	0	8	15	0	2
Ill:	Chicago	0	0	9	11	0	0	11	11	0	0
Ind:	Indianapolis	NA	NA	8	6	0	0	8	10	0	0
Iowa:	Des Moines	1	0	7	7	0	0	7	8	0	0
Kans:	Wichita	1	0	9	11	0	0	4	9	0	2
Ky:	Louisville	0	0	12	11	0	0	6	5	0	0
La:	New Orleans	0	0	23	24	0	0	25	31	0	0
Maine:	Portland	NA	NA	11	11	0	0	32	29	0	0
Md:	Baltimore	0	0	10	11	0	0	6	2	0	0
Mass:	Boston	0	0	12	14	0	0	26	19	0	0
Mich:	Detroit	NA	NA	8	8	0	0	12	10	0	0
	Grand Rapids	NA	NA	10	8	0	0	16	15	0	0
Minn:	Minneapolis	1	0	12	11	0	0	13	11	0	0
Miss:	Jackson	0	0	18	19	0	0	15	17	0	0
Mo:	Kansas City	1	0	8	10	0	0	4	4	1	0
	St. Louis	1	0	9	7	0	0	7	6	0	0
Mont:	Helena	1	0	6	6	0	0	8	10	1	3
Nebr:	Omaha	1	0	8	5	0	0	5	10	0	0
Nev:	Las Vegas	0	0	2	2	0	0	4	6	0	0
N. H:	Manchester	NA	NA	13	9	0	0	37	26	0	0
N. J:	Trenton	NA	NA	10	14	0	0	10	10	0	0
N. Mex:	Albuquerque	0	0	2	3	0	0	2	0	0	0
N. Y:	Buffalo	NA	NA	8	8	0	0	12	14	0	0
	New York City	NA	NA	10	11	0	0	14	15	0	0
	Syracuse [b]	NA	NA	7	10	0	0	10	9	0	0
N. C:	Charlotte	0	0	16	15	1	0	14	16	0	0
N. Dak:	Minot	3	0	12	13	0	0	12	18	0	0
Ohio:	Cincinnati	NA	NA	9	8	0	0	6	7	0	0
	Cleveland	NA	NA	9	10	0	0	10	12	0	0
Okla:	Oklahoma City	0	0	10	10	0	0	4	4	0	0
Ore:	Portland	1	0	7	8	0	0	14	18	0	0
Pa:	Philadelphia	NA	NA	8	0	0	0	8	4	0	0
	Pittsburgh	NA	NA	12	10	0	0	15	8	0	0
P. R:	San Juan	0	0	5	3	0	0	12	11	0	0
R. I:	Providence	NA	NA	11	12	0	0	20	10	0	0
S. C:	Charleston	0	0	15	15	0	0	30	28	0	0
S. Dak:	Rapid City	2	0	11	10	0	0	10	10	0	3
Tenn:	Chattanooga	0	0	15	13	0	0	14	14	0	0
	Memphis	0	0	12	14	0	0	5	8	0	0
Tex:	Austin	0	0	4	4	0	0	4	2	0	0
	Dallas	0	NA	8	0	0	0	6	11	0	0
Utah:	Salt Lake City	1	0	5	5	0	0	13	15	0	0
Va:	Norfolk	0	0	10	12	0	0	12	3	0	0
Vt:	Burlington	NA	NA	11	10	0	0	11	7	0	0
Wash:	Seattle	2	0	9	7	0	0	25	18	1	0
	Spokane	1	0	8	3	0	0	14	10	0	2
W. Va:	Charleston	0	0	11	10	0	0	6	3	0	0
Wisc:	Milwaukee	NA	NA	8	7	0	0	12	8	0	0
Wyo:	Laramie	0	0	5	4	0	0	6	3	0	0
Network monthly average		0	0	9	9	0	0	13	11	0	0

[a] See text for averaging procedure.
[b] 12 month averages represent only 9-months data.
NA, no analysis.

Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. Table 2 contains averages for April 1968 and 12-month averages for the period May 1967 through April 1968. The

12-month averages facilitate evaluations of population exposure with respect to the guidance provided by the Federal Radiation Council, which suggests average total daily intakes "averaged over periods of the order of a year," as an appropriate criterion (*3*). The average radionuclide concentrations are based on results obtained from samples collected weekly. Whenever weekly concentrations were less than or equal to the appropriate minimum detectable levels, zero was used for averaging purposes (*2*). At very low radionuclide concentrations this often results in averages lower than the minimum detectable concentration for a single sample, but any positive value reflects at least one weekly sample which was above the minimum detectable level. The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in units of pCi/liter are: strontium–89, 5; strontium–90, 2; cesium–137, barium–140, and iodine–131, 10. Iodine–131 is not shown in table 2 as the concentrations were below detectable levels.

The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

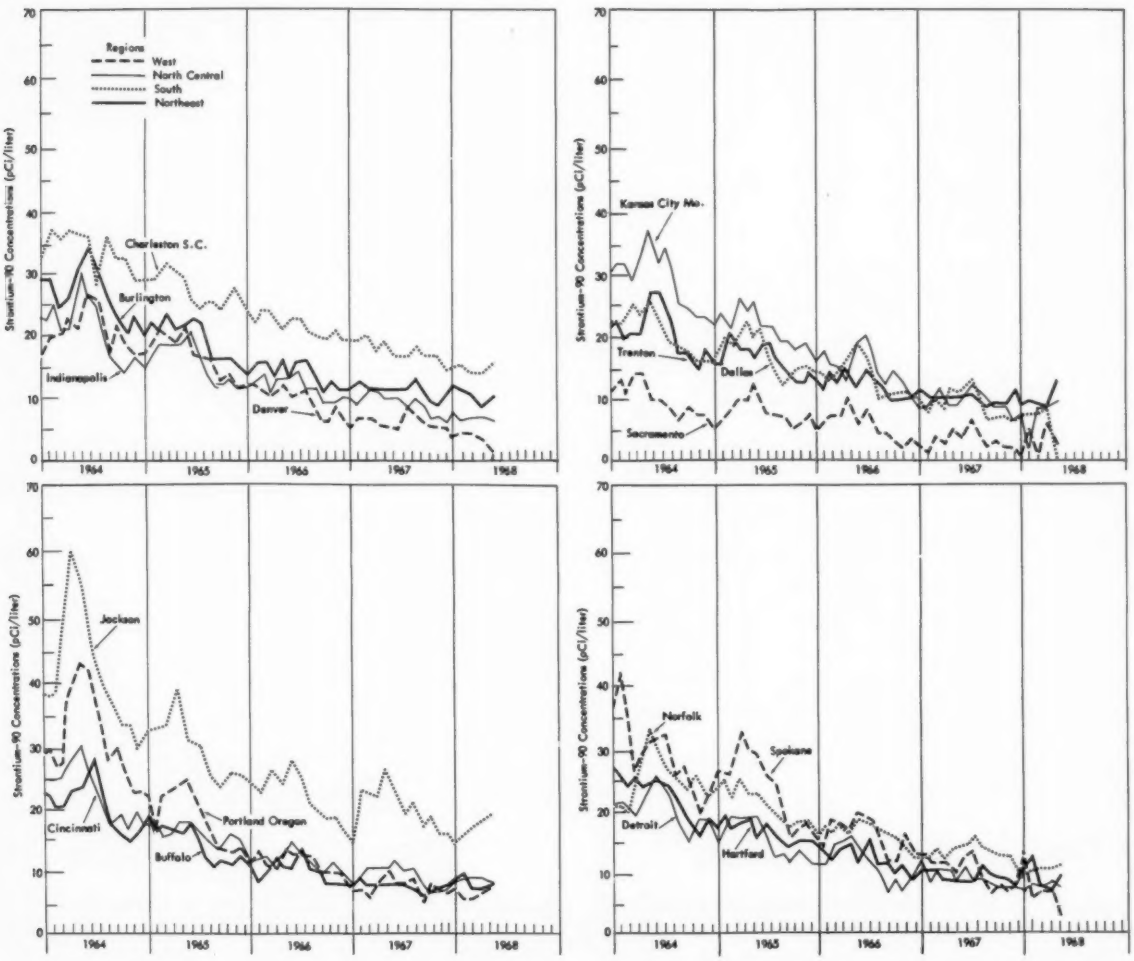

Figure 2. Strontium–90 concentrations in pasteurized milk, 1964–April 1968

2. Canadian Milk Network April 1968[1]

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the April 1968 issue of *Radiological Health Data and Reports* (*4*).

The April 1968 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 3. Iodine–131 concentrations were below minimum detectable levels. Due to the low environmental levels currently present, strontium–89 analysis has been discontinued.

[1] Prepared from May 1968 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 3. Stable elements and radionuclides in Canadian whole milk, April 1968

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.15	1.4	8	15
Edmonton	1.13	1.5	8	19
Ft. William	1.10	1.4	14	28
Fredericton	1.07	1.6	15	25
Halifax	1.09	1.5	11	24
Montreal	1.09	1.5	10	21
Ottawa	1.13	1.5	8	14
Quebec	1.09	1.5	15	29
Regina	1.09	1.5	6	14
St. John's, Nfld.	1.11	1.4	17	30
Saskatoon	1.10	1.5	8	17
Sault Ste. Marie	1.08	1.5	15	23
Toronto	1.09	1.5	5	12
Vancouver	1.11	1.5	14	47
Windsor	1.15	1.4	6	10
Winnipeg	1.08	1.6	8	23

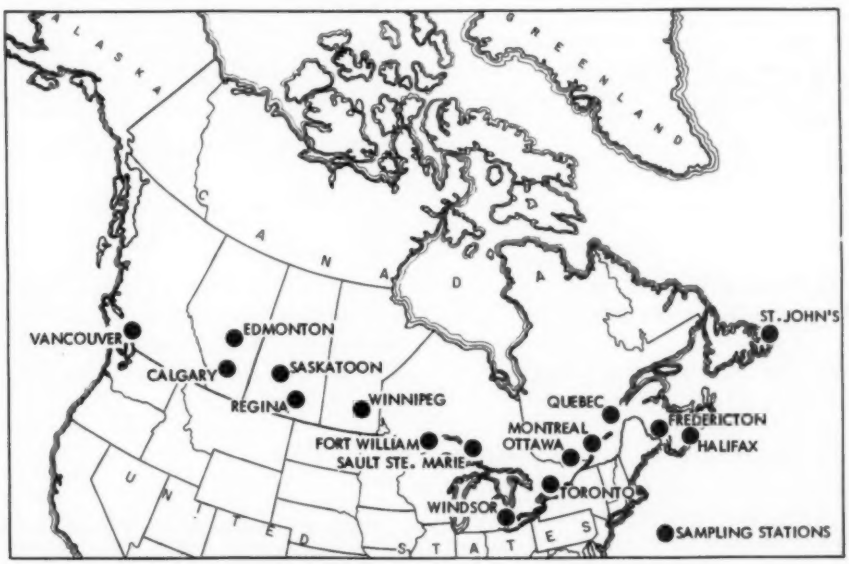

Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program April 1968

Pan American Health Organization and *U.S. Public Health Service*

The Pan American Health Organization (PAHO) in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (*5*).

Table 4 presents stable potassium, strontium–90 and cesium–137 monthly concentrations for April 1968.

Table 4. Stable element and radionuclide concentration in Pan American milk,[a] April 1968

Sampling station	Number of samples	Potassium (g/liter)	Strontium-90 [b] (pCi/liter)	Cesium-137 [b] (pCi/liter)
Chile: Santiago	1	1.62	0	0
Colombia: Bogota	1	1.44	0	0
Ecuador: Guayaquil	1	1.50	0	0
Jamaica: Kingston	1	1.51	4	60
Venezuela: Caracas	1	1.59	0	0
Canal Zone: Cristobal [c]	5	1.47	0	3
Puerto Rico: San Juan [c]	5	1.60	3	11

[a] All strontium-89 results were ≤5 pCi/liter; iodine-131 and barium-140 results were all ≤10 pCi/liter.
[b] Strontium-90 single sample results ≤2 pCi/liter and cesium-137 single sample results ≤10 pCi/liter are reported as 0.
[c] For comparison, the radionuclide concentrations in Pasteurized Milk Network samples collected at Cristobal, Canal Zone, and San Juan, Puerto Rico, are presented.

Figure 4. Pan American Milk Sampling Program stations

4. Radiostrontium in milk January–December 1967[2]

Health and Safety Laboratory
U.S. Atomic Energy Commission

In 1954, the Health and Safety Laboratory began monitoring strontium–90 in liquid whole milk in New York to estimate the dietary contribution from ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, N.Y. (1954), and at Mandan, N. Dak. (1955). Liquid whole milk monitoring was started in Honolulu, Hawaii, in August 1959. Sampling was terminated at Mandan, N. Dak., and Honolulu, Hawaii at the end of June 1965.

[2] Data summarized from "Fallout Program Quarterly Summary Report," HASL–193, available from Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

Table 7. Strontium–90 to calcium ratios in milk, January–December 1967

Sampling location	Strontium-90 to calcium ratio (pCi ^{90}Sr/g Ca)											
	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
New York, N.Y. (liquid whole milk)	13.5	9.6	11.1	10.9	9.7	—	—	—	12.2	7.6	7.8	7.4
Perry, N.Y. (powdered whole milk)	9.5	8.9	9.8	7.6	8.2	8.5	7.5	9.3	8.1	8.6	7.5	7.1

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Perry samples are monthly composites of powdered whole milk for human consumption collected weekly in 5-pound lots from plants in the city. The strontium–90 to calcium ratios in whole milk are presented in table 7.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1966	March 1967
July–December 1966	September 1967

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, September 1967. Radiol Health Data Rep 9:20–23 (January 1968).

(*2*) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, October 1967. Radiol Health Data Rep 9:86–89 (February 1968).

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(4) DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION. Canadian milk network, August 1966. Radiol Health Data Rep 7:702–703 (December 1966).

(*5*) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1966. Radiol Health Data Rep 7:704–705 (December 1966).

State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

Figure 1 shows the States which report milk surveillance activities in *Radiological Health Data and Reports*. States having programs appearing in this issue are highlighted in the figure. Following is a summary of previously covered State programs, their reporting period, and the last issue in which they appeared.

State milk network	Period reported	Last presented
Colorado	January–March 1968	July 1968
Florida	January–March 1968	July 1968
Oklahoma	October–December 1967	April 1968
Tennessee	January–March 1968	July 1968
Texas	January–March 1968	July 1968
Washington	October–December 1967	June 1968
California	October–December 1967	June 1968
Oregon	October–December 1967	June 1968

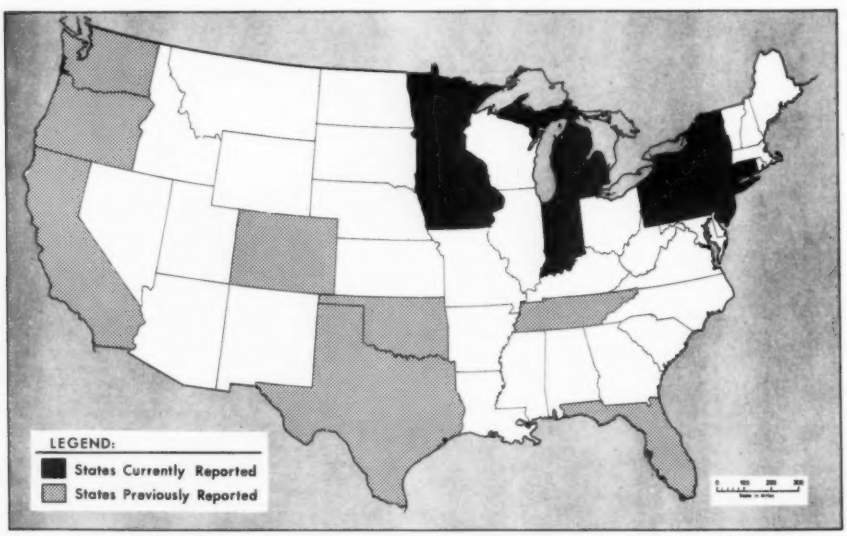

Figure 1. State milk surveillance activities

1. Connecticut Milk Network January–March 1968

Connecticut State Department of Health

The Connecticut State Department of Health has been monitoring pasteurized milk for strontium–89 and strontium–90 since April 1960. In May 1962, the program was expanded to include the determination of gamma-emitting radionuclides in milk.

The sampling program is flexible in nature, providing for sampling in five areas of the State (figure 2). At the present time, weekly samples representative of milk sold in the central area of the State are collected and analyzed for strontium–89, strontium–90, and gamma-ray emitters. Concentrations of iodine–131 are determined as an indication of the presence of radioactivity of recent origin.

Strontium–89 and strontium–90 are determined by chemical separation. Iodine–131 and other gamma-ray emitters are determined by gamma-ray scintillation spectroscopy.

The monthly average concentrations of strontium–89, strontium–90, iodine–131, and cesium–137 in central Connecticut pasteurized milk are presented in table 1. These results are presented graphically in figure 3.

Table 1. Radionuclide concentrations in central Connecticut pasteurized milk, January–March 1968

Month	Concentration (pCi/liter)			
	Strontium-89	Strontium-90	Iodine-131	Cesium-137
January	ND	7	<10	15
February	ND	8	<10	10
March	ND	7	<10	10

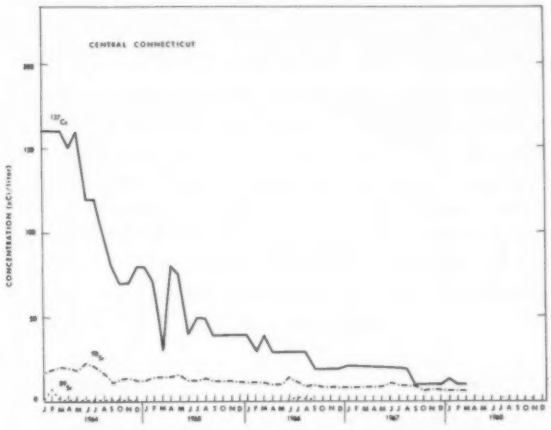

Figure 3. Radionuclide concentrations in central Connecticut pasteurized milk, 1964–March 1968

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1967	February 1968
October–December 1967	May 1968

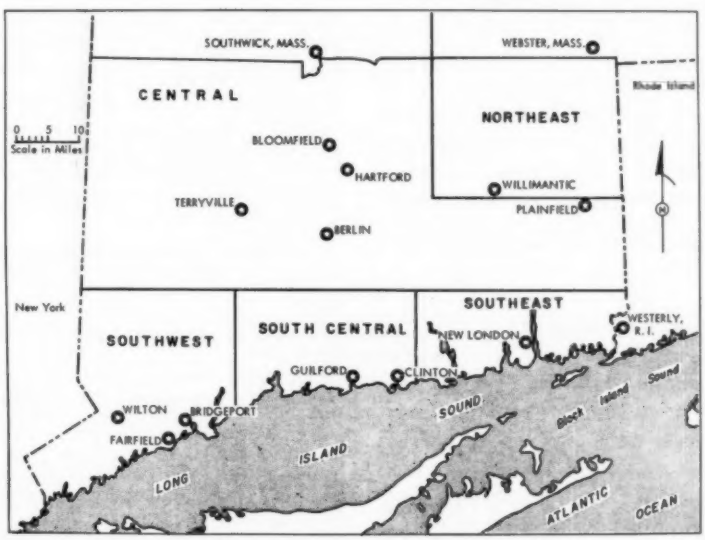

Figure 2. Connecticut pasteurized milk sampling areas

2. Indiana Milk Network January–March 1968

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radionuclide analysis in September 1961. The State was geographically divided into five major milksheds; northeast, northwest, central, southeast, and southwest (figure 4). One large dairy within each milkshed was assumed to be representative for sampling purposes.

The milk samples are analyzed monthly for strontium–89 and strontium–90. Cesium–137, iodine–131, and barium–140 are analyzed weekly for at least two of the milksheds. When iodine–131 concentrations exceed 100 pCi/liter, the sampling frequency is increased. From August 1963 to April 1966, because of the continued low concentrations of short-lived radionuclides, the sampling frequency was once a month for the northeast, southeast, and southwest milksheds.

Strontium–89 and strontium–90 concentrations in milk samples are determined by ion exchange separation (*1*, *2*) while cesium–137, iodine–131, and barium–140 are determined by gamma-ray scintillation spectrometry (*3*).

The monthly stable elements and radionuclide concentrations in Indiana pasteurized milk are presented by sampling locations in table 2 for January through March 1968. Barium–140, iodine–131 and strontium–89 concentrations remained below detectable levels of 10 pCi/liter during this period.

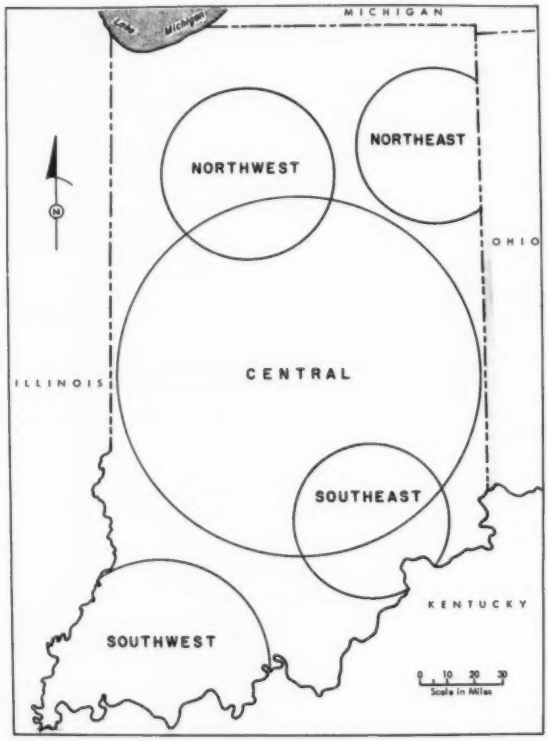

Figure 4. Indiana pasteurized milk sampling areas

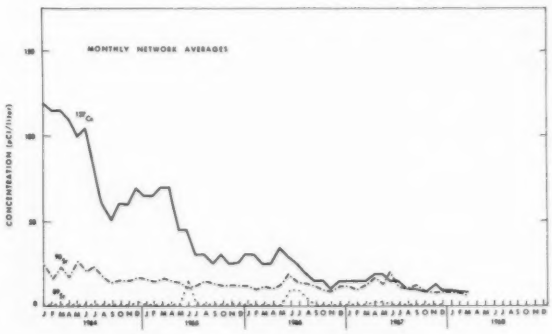

Figure 5. Radionuclide concentrations in Indiana pasteurized milk, 1964–March 1968

Table 2. Stable elements and radionuclide concentrations in Indiana milk January–March 1968

Sampling location	Calcium (g/liter)			Potassium (g/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
Northeast	1.19	1.18	1.17	1.49	1.62	1.52	7	8	7	5	5	10
Southeast	1.17	1.20	1.24	1.47	1.51	1.67	9	10	6	5	15	10
Central	1.21	1.25	1.28	1.53	1.58	1.48	9	7	6	10	10	5
Southwest	1.14	1.18	1.18	1.52	1.59	1.58	10	10	8	20	5	10
Northwest	1.26	1.20	1.42	1.57	1.57	1.51	8	8	7	10	10	10

The monthly network average concentrations of strontium–89, strontium–90, and cesium–137 are presented graphically in figure 5.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1967	February 1968
October–December 1967	May 1968

3. Iowa Milk Network January March 1968

State Hygienic Laboratory and *the Iowa State Department of Health*

In Iowa, radiological health activities are conducted jointly by the State Department of Health and the State Hygienic Laboratory, with the State Hygienic Laboratory performing the surveillance and analytical functions.

In August 1962 the State Hygienic Laboratory of Iowa began sampling milk for iodine–131. In May 1964 this routine surveillance was expanded to include cesium–137 and strontium–90.

One gallon samples are collected from 4 stations, selected to give a broad coverage of milk production areas in the State (figure 6). Producers furnishing milk to the Spencer bottling area are quite restricted to that northwest part of the state and the majority of milk bottled in Iowa City comes from six counties in east central Iowa. The Des Moines milkshed comprises approximately sixty counties covering about two thirds of the state radiating out of Des Moines in all directions. The Charles City bottling area covers primarily north central Iowa. At present the Iowa City and Des Moines stations are sampled weekly and the Spencer and Charles City stations are sampled monthly. The sampling frequency is increased when nuclide concentrations warrant closer surveillance. The samples are forwarded to the State Hygienic Laboratory at the University of Iowa, Iowa City for analysis.

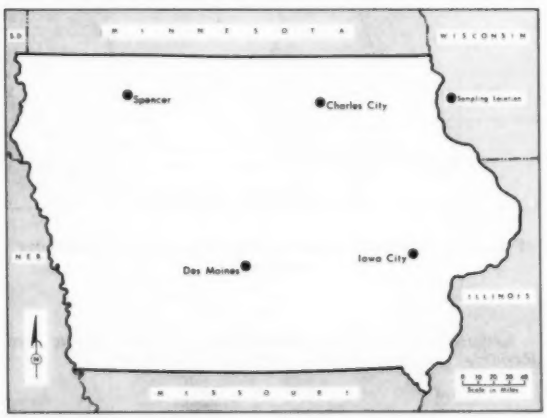

Figure 6. Iowa milk sampling locations

Analytical procedures

Iodine–131 and cesium–137 together with barium-lanthanum–140 and potassium–40 are determined by gamma-scintillation spectrometry using a 4- by 4-inch NaI (Tl) crystal and 512 channel pulse height analyzer. All samples are 3.5 liters and are counted for 80 minutes in Marinelli beakers with the results being calculated using a 4 by 4 matrix. Strontium–90 is determined by an ion-exchange system described by Porter, et al (4). One liter of milk is passed through an ion-exchange column; yttrium–90 is eluted from the resin and counted as yttrium oxalate in an automatic low background proportional counter. Minimum detectable limits are 10 pCi/liter for iodine–131 and cesium–137 and 2 pCi/liter for strontium–90.

Results

Table 3 gives the monthly averages at each of the four locations for January–March 1968 and figure 7 shows graphically the overall network average monthly results. During this period it can be seen that the concentration levels of cesium–137 and strontium–90 showed a decreasing trend. Iodine–131 was only present to any significant amount during the month of June 1965.

Table 3. Radionuclide concentrations in Iowa milk January–March 1968

Sampling location	Concentration (pCi/liter)								
	Strontium-90			Cesium-137			Iodine-131		
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
Iowa City	6	6	7	<10	<10	<10	<10	<10	<10
Des Moines	7	7	5	<10	<10	<10	<10	<10	<10
Spencer	5	8	8	<10	<10	<10	<10	<10	<10
Charles City	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA, no analysis.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1967	February 1968
October–December 1967	May 1968

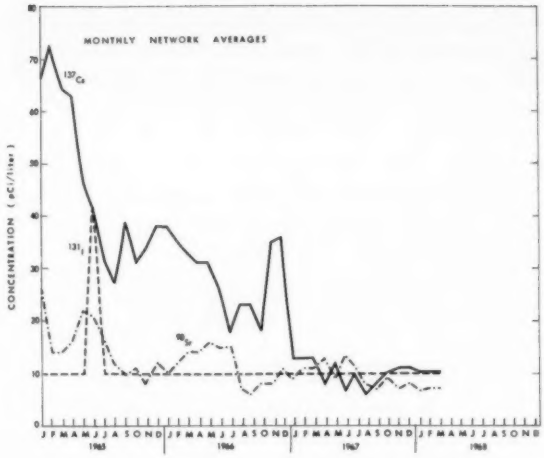

Figure 7. Radionuclide concentrations in Iowa milk 1965–March 1968

4. Michigan Milk Network January–March 1968

Division of Occupational Health
Michigan Department of Health

The Michigan Department of Health began sampling pasteurized milk for radionuclide analyses in November 1962. Under this program, weekly pasteurized milk samples are collected in the seven major milk producing areas in the State: Charlevoix, Detroit, Grand Rapids, Lansing, Marquette, Monroe, and Saginaw (figure 8). Milkshed samples are composites of dairies in proportion to sales volumes.

Strontium–90 concentrations are determined by an ion exchange method (*5*). Potassium–40, iodine–131, cesium–137, and barium-lanthanum–140 concentrations are determined by gamma-ray scintillation spectrometry (*5*).

Table 4 presents the monthly average stable elements and radionuclide concentrations in Michigan pasteurized milk. Iodine–131 levels were less than the minimum detectable radioactivity (14 pCi/liter) for the period at all stations. Strontium–90 and cesium–137 concentrations are presented graphically in figure 9 to show general trends.

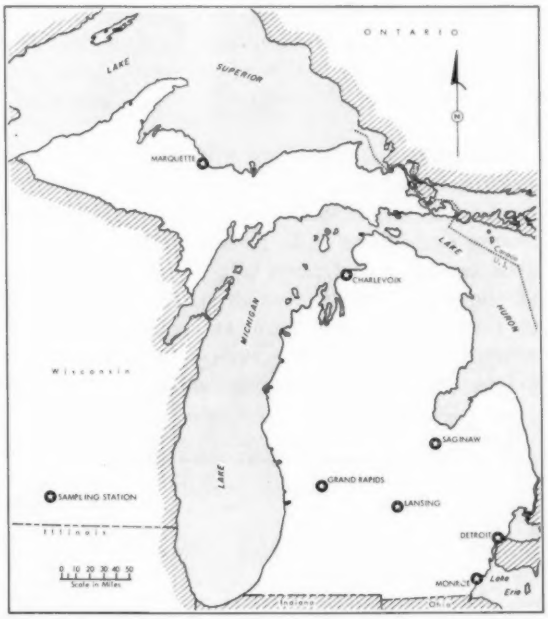

Figure 8. Michigan pasteurized milk network sampling locations

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1967	February 1968
October–December 1967	May 1968

Table 4. Stable element and radionuclide concentrations in Michigan pasteurized milk, January–March 1968

Sampling location	Month	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Charlevoix	January	1.62	6	8
	February	1.67	5	10
	March	1.69	5	13
Detroit	January	1.69	6	5
	February	1.68	4	7
	March	1.68	4	8
Grand Rapids	January	1.64	7	10
	February	1.68	4	11
	March	1.65	5	9
Lansing	January	1.65	5	8
	February	1.72	3	4
	March	1.69	4	5
Marquette	January	1.65	6	12
	February	1.83	6	17
	March	1.68	7	16
Monroe	January	1.65	4	8
	February	1.70	3	8
	March	1.74	3	7
Bay City	January	1.69	4	7
	February	1.70	3	6
	March	1.72	5	7

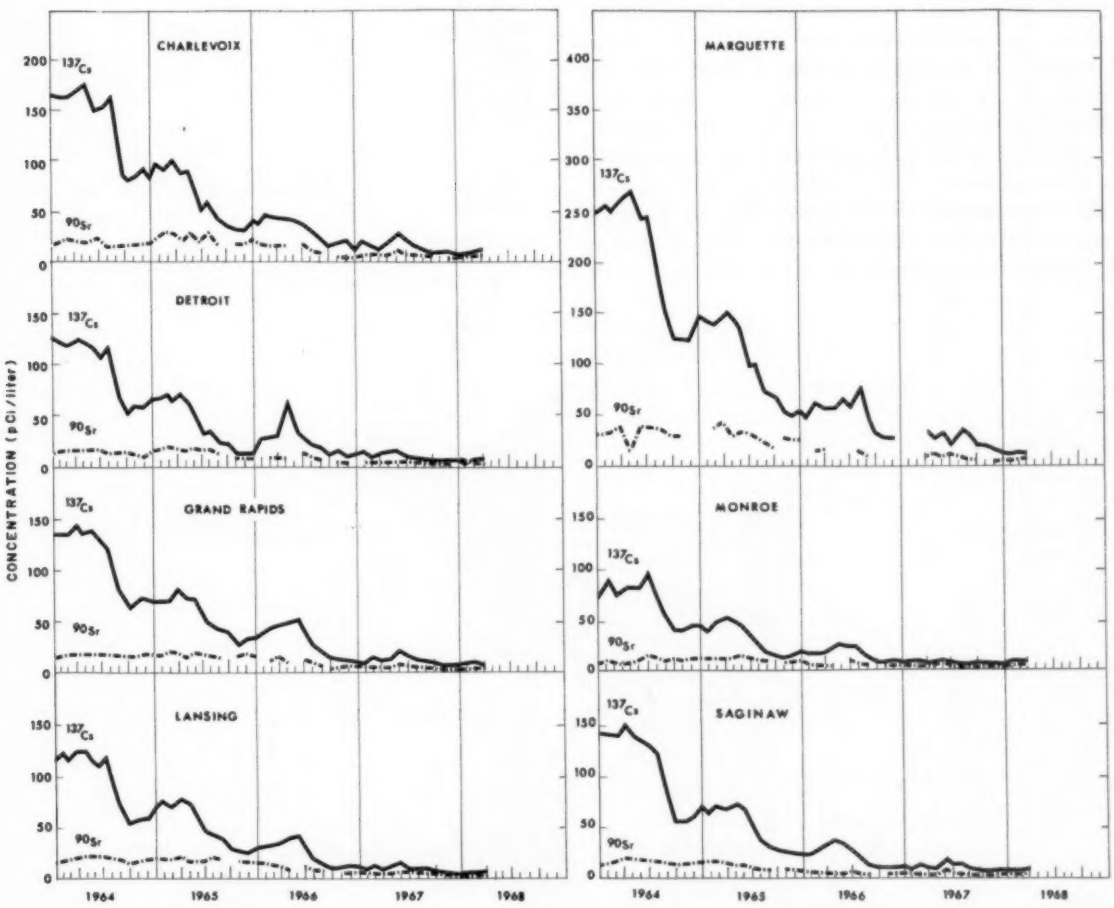

Figure 9. Radionuclide concentrations in Michigan pasteurized milk, 1964–March 1968

5. Minnesota Milk Network January–March 1968

Division of Environmental Health
Minnesota Department of Health

In September 1958, the Minnesota Department of Health initiated a pasteurized milk network to monitor strontium–90 concentrations. Monitoring of iodine–131 concentrations commenced in October 1961 and of cesium–137 concentrations in July 1963. Until recently, 1–liter samples were collected from eight sampling locations in milksheds geographically the same as the Minnesota health districts (figure 10) and analyzed for strontium–90, iodine–131 and cesium–137. The size of the sample has been increased to 2 quarts for more accurate determinations. The 2-quart samples of processed Grade A fluid milk are collected in the cities where the Minnesota Health Department district offices are located.

Strontium–90 concentrations are determined radiochemically, while iodine–131 and cesium–137 concentrations are determined by gamma-ray scintillation spectrometry. The analytical procedures are presented in the semiannual report of the Minnesota Department of Health and the Rural Cooperative Power Association (*6*).

Strontium–90, and cesium–137 concentrations in milk are given for January through March 1968 in table 5, and are presented graphically by milkshed in figure 11 for the period 1961 through March 1968. Iodine–131 concentrations were less than 10 pCi/liter in all 24 samples.

Table 5. Radionuclide concentrations in Minnesota pasteurized milk, January–March 1968

Sampling stations	Radionuclide concentration (pCi/liter)					
	Strontium-90			Cesium-137		
	Jan	Feb	Mar	Jan	Feb	Mar
Bemidji	13	11	10	9	17	17
Mankato	6	5	5	6	11	10
Rochester	7	8	5	5	8	5
Duluth	16	20	16	14	34	19
Worthington	6	5	5	9	8	9
Minneapolis	10	10	9	9	9	8
Fergus Falls	8	7	6	8	7	8
Little Falls	8	6	8	8	13	12

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1967	February 1968
October–December 1967	May 1968

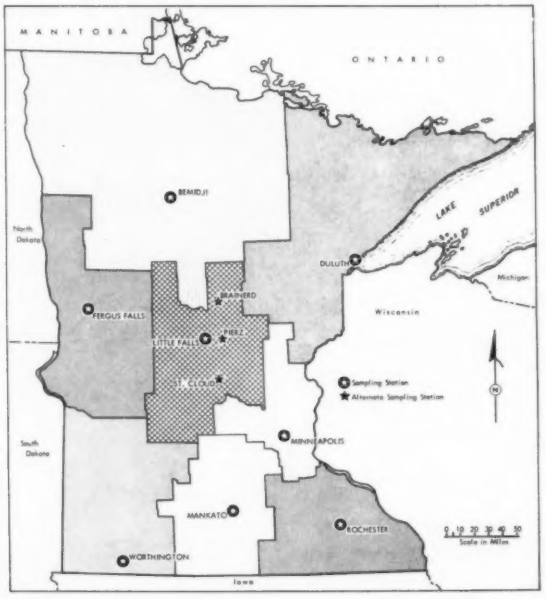

Figure 10. Minnesota milk sampling locations

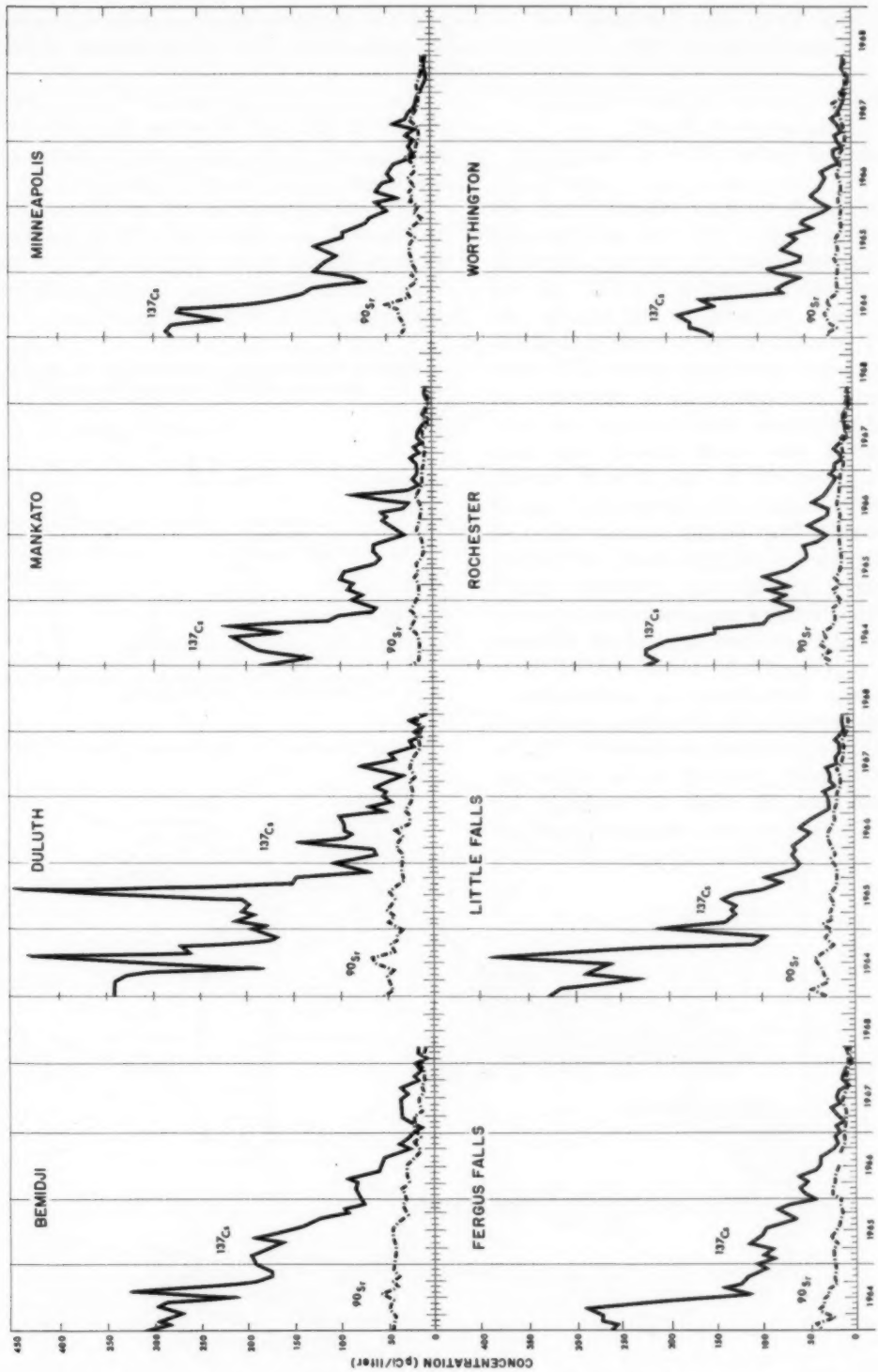

Figure 11. Radionuclide concentrations in Minnesota milk, 1964–March 1968

6. New York Milk Network January–March 1968

Division of General Engineering and Radiological Health
Department of Health, State of New York

Pasteurized milk samples collected routinely from six cities (figure 12) are analyzed for strontium–89, strontium–90, iodine–131, cesium–137 and barium–lanthanum–140 by the New York State Department of Health. At Buffalo and Newburgh, milk samples are collected daily from processing plants and composited weekly for radiochemical analyses. At Massena and Syracuse daily samples are composited over a two week period and then analyzed. In New York City, a milk sample representing the total milk supply for 1 day is analyzed weekly. The Albany sample, taken at a marketing point, is analyzed daily for iodine–131 and other gamma-ray emitting radionuclides before being composited into a weekly sample. In the event that any sample contains iodine–131 concentrations exceeding 100 pCi/liter, increased surveillance is undertaken.

Gamma-ray emitting radionuclides in milk are determined by scintillation spectrometry. Radioiodine is selectively removed in an anion exchange resin and the resin is analyzed for iodine–131 (*7*, *9*). The resin effluent is analyzed and the resulting spectral data is resolved by the application of a matrix method of analysis (*8*).

The analytical procedure for determining strontium–89 and strontium–90 concentrations employs an ion-exchange system similar to that developed by Porter and Kahn (*2*).

The concentrations of strontium–90 and cesium–137 are shown in table 6 for January through March 1968. Cesium–137 and iodine–131 concentrations since September 1961 are presented graphically in figure 13.

Table 6. Radionuclide concentrations in New York pasteurized milk, January–March 1968

Sampling location	Radionuclide concentrations (pCi/liter)			
	Strontium-90		Cesium-137	
	Number of samples	Average	Number of samples	Average
Albany	10	7	6	ND
Buffalo	6	7	4	20
Massena	5	10	5	ND
Newburgh	5	8	4	ND
New York	10	12	5	21
Syracuse	3	11	3	20

ND, nondetectable. Detectable limits for strontium-90 and cesium-137 are 3 pCi/liter and 20 pCi/liter, respectively.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April–June 1967	November 1967
December 1967	May 1968

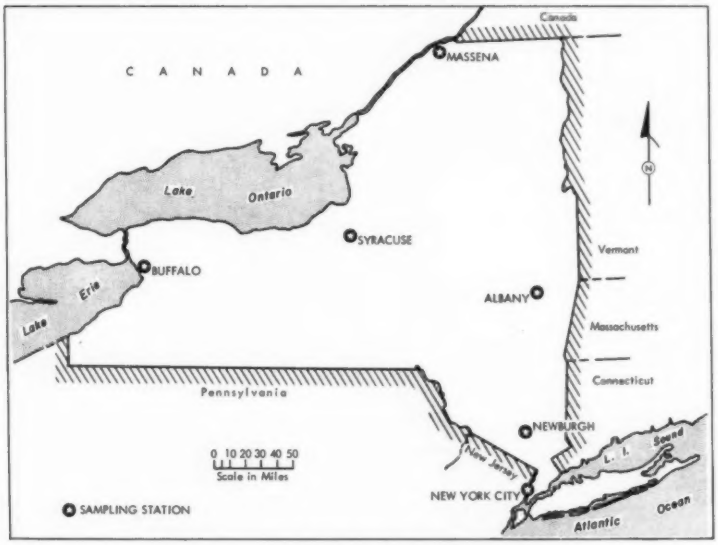

Figure 12. New York milk sampling locations

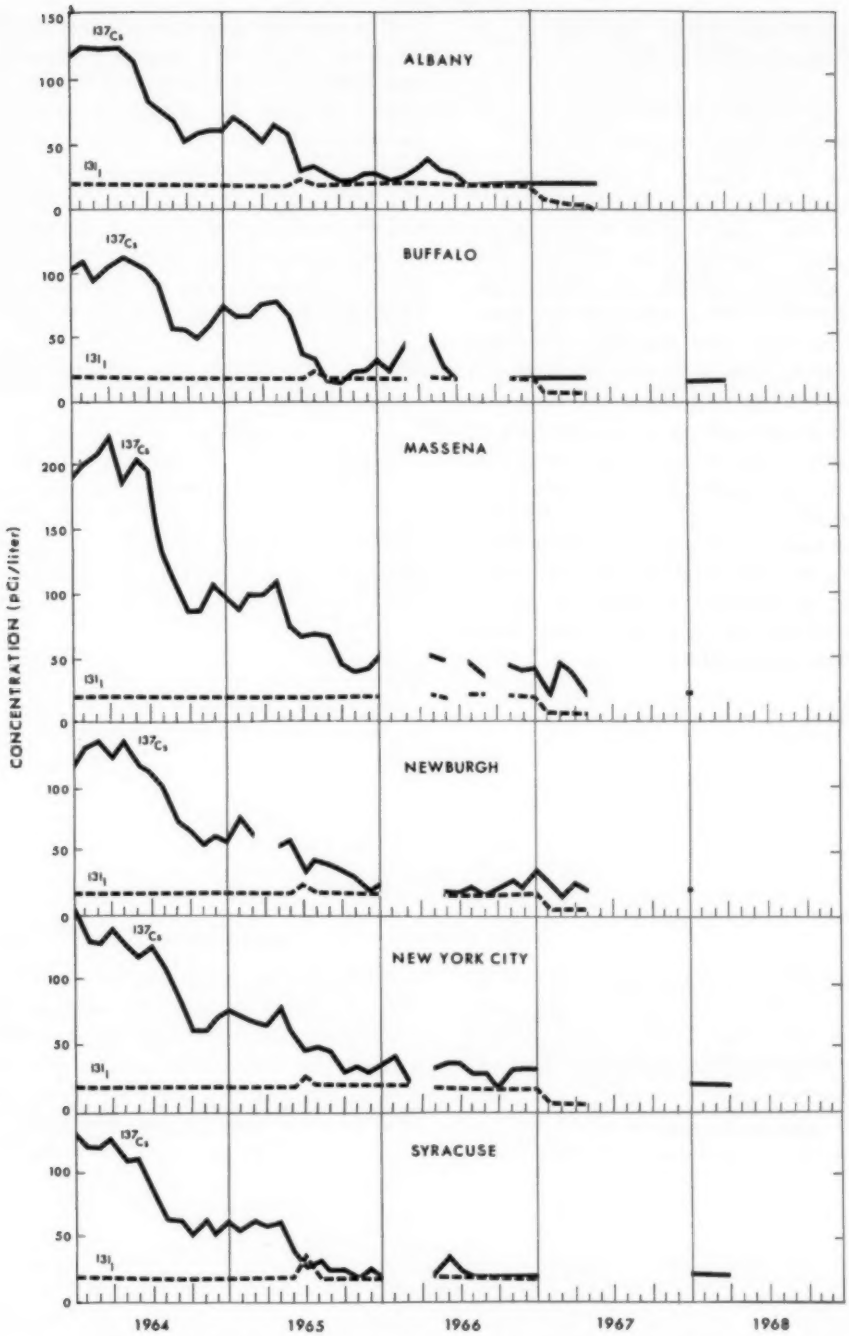

Figure 13. Radionuclide concentrations in New York milk, 1964–March 1968

7. Pennsylvania Milk Network January–March 1968

Bureau of Environmental Health
Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from six major milk consumption areas throughout Pennsylvania (figure 14). Samples are collected weekly in Pittsburgh, while biweekly composite samples are collected from the other five stations. At each sampling location, subsamples are collected from the major dairies supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite is then sent to the Radiation Laboratory of the Division of Occupational Health in Harrisburg where the samples are analyzed for iodine–131, potassium–40, and cesium–137 and then composited for a monthly analysis of strontium–90. Strontium–90 analyses have been carried out since April 1963.

The monthly average potassium, strontium–90, and cesium–137 concentrations in pasteurized milk are given in table 7. Iodine–131 levels were less than the minimum detectable radioactivity (10 pCi/liter) at all stations for this period. For comparative purposes, strontium–90, iodine–131, and cesium–137 concentrations are presented graphically in figure 15.

The chemical separation technique for strontium–90 is essentially an ion-exchange method described by Porter, et al. (*1*).

Table 7. Radionuclide concentrations in Pennsylvania pasteurized milk, January–March 1968

Sampling location	Potassium (g/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
Altoona	1.61	1.50	1.65	6	6	6	12	13	11
Dauphin	1.60	1.68	1.60	6	6	5	11	8	10
Erie	1.53	1.66	1.64	6	13	13	14	12	13
Philadelphia	1.54	1.57	1.52	5	5	8	14	11	14
Pittsburgh	1.54	1.59	1.58	10	7	13	11	12	16
York	1.57	1.69	1.50	3	4	7	15	15	15

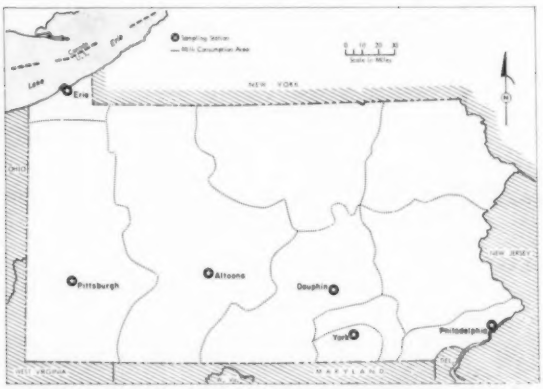

Figure 14. Pennsylvania pasteurized milk network sampling stations

Figure 15. Radionuclide concentrations in Pennsylvania milk, 1964–March 1968

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1967	February 1968
October–December 1967	May 1968

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(1) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY and B. KAHN. Determination of strontium–90 in milk by an ion exchange method. Anal Chem 33:1306–1308 (September 1961).
(2) PORTER, C., and B. KAHN. Improved determinations of strontium–90 in milk by an ion exchange method. Anal Chem 36:676–678 (March 1964).
(3) INDIANA STATE BOARD OF HEALTH, BUREAU OF ENVIRONMENTAL SANITATION: Indiana milk network, April–June 1965. Radiol Health Data 6:612–614 (November 1965).
(4) PORTER, C., R. AUGUSTINE, J. MATUSEK, JR., and M. CARTER. Procedures for determination of stable elements and radionuclides in environmental samples. Public Health Service Publication No. 999–RH–10. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (January 1965).
(5) MICHIGAN DEPARTMENT OF HEALTH. Michigan milk network, November 1962–December 1964. Radiol Health Data 6:487–492 (September 1965).
(6) MINNESOTA DEPARTMENT OF HEALTH AND RURAL COOPERATIVE POWER ASSOCIATION. Survey of environmental radioactivity, January–June 1965, COO–615–17 (August 1965).
(7) JOHNSON, R. H. and T. C. REAVY. Evaluation of ion exchange cartridges for field sampling of iodine–131 in milk. Nature 208:750–752 (November 1965).
(8) KAHN, B., G. K. MURTHY, C. PORTER, G. R. HAGEE, G. J. KARCHES, and A. S. GOLDIN. Rapid methods for estimating fission product concentrations in milk. PHS Publication No. 999–R–2 (March 1963).
(9) PORTER, C. R., and M. W. CARTER. Field method for rapid collection of iodine–131 from milk. Public Health Rep 80:453–456 (May 1965).

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period Reported	Last presented
California Diet Study	July–October 1967	May 1968
Connecticut Standard Diet	July–December 1967	May 1968
Institutional Total Diet	October–December and annual summary	July 1968
Tri-City Diet, HASL	April–December 1967	June 1968

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determination of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium–90, respectively.

Water sampling program	Period reported	Last presented
California	January–June 1967	June 1968
Colorado River Basin	1965–1966	May 1968
Coast Guard	January–December 1966	November 1967
Florida	1965–1966	July 1968
Minnesota	January–June 1967	January 1968
New York	January–May 1967	January 1968
Radiostrontium in Tap Water, HASL	July–December 1967	June 1968

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office. Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States, February 1968

Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium–90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended- plus dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the August 1967 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity concentration is 15 pCi/liter or greater or when the beta radioactivity concentration is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes

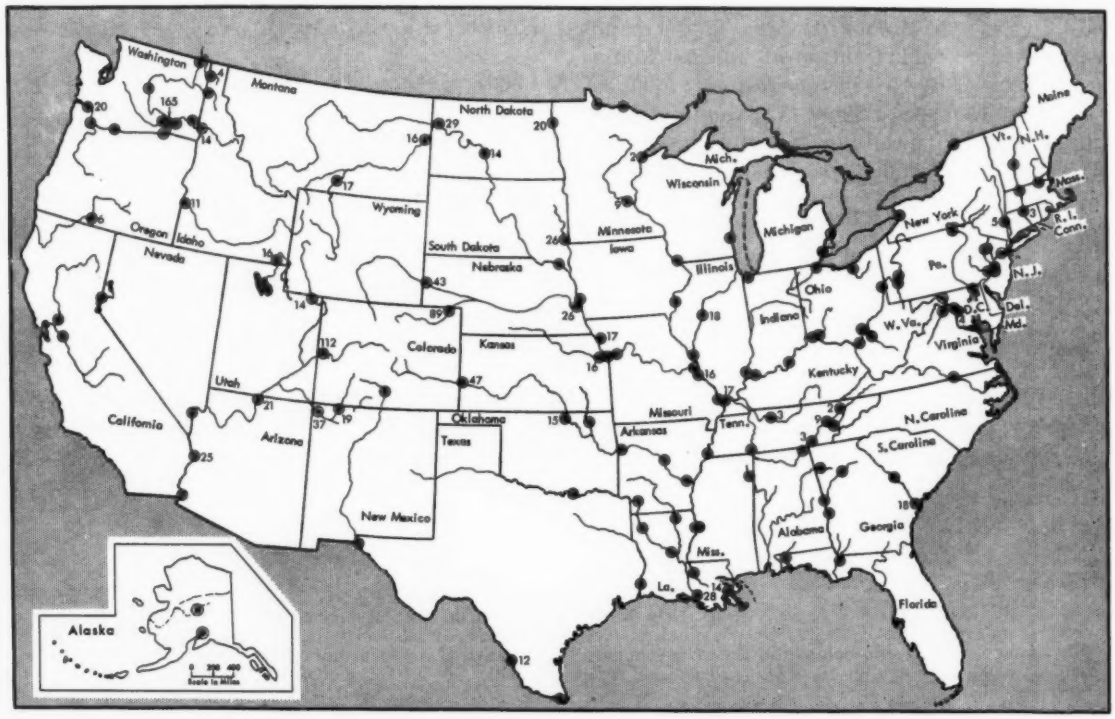

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, February 1968

from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveillance System for 1961 through 1965 has been presented (*7*). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During February 1968, the following stations showed values in excess of 15 pCi/liter of alpha radioactivity for dissolved solids:

Arkansas River; Coolidge, Kans.
North Platte River; Henry, Nebr.
South Platte River; Julesburg, Colo.

During February 1968, Pasco, Wash., on the Columbia River decreased in average beta radioactivity to slightly less than 150 pCi/liter in dissolved solids.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*2*) Ibid., 1959 Edition.
(*3*) Ibid., 1960 Edition.
(*4*) Ibid., 1961 Edition.
(*5*) Ibid., 1962 Edition.
(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*7*) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1–12 (January 1968).

Table 1. Radioactivity in raw surface waters, February 1968

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	2	1	3	11	8	19
Arkansas River:						
Coolidge, Kans.	1	23	24	6	41	47
Ponca City, Okla.	0	2	2	1	14	15
Atchafalaya River:						
Morgan City, La.	4	1	5	21	7	28
Bear River:						
Preston, Idaho	0	2	2	1	15	16
Big Horn River:						
Hardin, Mont.	1	2	3	3	14	17
Big Sioux River:						
Sioux Falls, S. Dak.	0	2	2	<1	26	26
Clearwater River:						
Lewiston, Idaho	2	0	2	7	7	14
Clinch River:						
Clinton, Tenn.	0	0	0	0	2	2
Kingston, Tenn [a]	0	0	0	1	8	9
Colorado River:						
Loma, Colo.	10	6	16	36	76	112
Page, Ariz.	1	5	6	1	20	21
Parker Dam, Calif.-Ariz.	0	5	5	1	24	25
Columbia River:						
Pasco, Wash [a]	<1	<1	<1	20	145	165
Clatskanie, Ore.	0	0	0	7	13	20
Connecticut River:						
Enfield Dam, Conn.	0	0	0	1	2	3
Cumberland River:						
Cheatham Lock, Tenn.	0	0	0	1	2	3
Great Lakes:						
Duluth, Minn.	0	0	0	0	2	2
Green River:						
Dutch John, Utah	1	2	3	1	13	14
Hudson River:						
Poughkeepsie, N. Y.	0	0	0	0	5	5
Illinois River:						
Peoria, Ill.	2	0	2	8	10	18
Kansas River:						
DeSoto, Kans.	0	4	4	1	15	16
Klamath River:						
Keno, Ore.	0	0	0	1	5	6
Mississippi River:						
St. Paul, Minn.	0	1	1	0	9	9
E. St. Louis, Ill.	2	1	3	7	9	16
New Orleans, La.	1	0	1	7	7	14
Missouri River:						
Williston, N. Dak.	5	2	7	19	10	29
Bismarck, N. Dak.	<1	3	3	1	13	14
St. Joseph, Mo.	1	2	3	3	14	17
North Platte River:						
Henry, Nebr.	<1	30	30	4	39	43
Ohio River:						
Cairo, Ill.	2	0	2	11	6	17
Pend Oreille River:						
Albeni Falls Dam, Idaho	0	<1	<1	<1	4	4
Platte River:						
Plattsmouth, Nebr.	2	3	5	9	17	26
Potomac River:						
Washington, D. C.	0	0	0	1	3	4
Red River, North:						
Grand Forks, N. Dak.	0	1	1	1	19	20
Rio Grande:						
Laredo, Tex.	0	4	4	1	11	12
San Juan River:						
Shiprock, N. Mex.	12	2	14	29	8	37
Savannah River:						
Port Wentworth, Ga [a]	<1	0	<1	4	14	18
Snake River:						
Payette, Idaho	1	1	2	2	9	11
South Platte River:						
Julesburg, Colo.	3	43	46	15	74	89
Tennessee River:						
Chattanooga, Tenn.	0	<1	<1	<1	3	3
Yellowstone River:						
Sidney, Mont.	0	4	4	1	15	16
Maximum	12	43	46	36	145	165
Minimum	0	0	0	0	2	2

[a] Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

Radioactivity in Washington Surface Water, July 1966–June 1967 [1]

Washington State Department of Health

Radioanalysis of surface water samples collected throughout the State of Washington is one of the major functions of the Washington State Department of Health radiation surveillance program. Most surface water samples are collected quarterly or semiannually by the Washington State Water Pollution Control Commission. Selected stations on the Columbia River are sampled weekly or monthly by local health departments. Cedar River, a major water supply for the greater Seattle area, is sampled monthly by the City of Seattle Water Department.

All surface water samples are collected as grab samples in 2-liter polyethylene bottles. To prevent loss of radioactivity to the container, 2 milliliters of concentrated nitric acid are added to the sample before shipment to the State laboratory in Seattle for analysis.

Analytical procedures

Surface water samples are divided into two groups: those samples coming from the Columbia River and those samples coming from waters other than the Columbia River. The latter samples are placed in stainless-steel Marinelli beakers for gamma-ray spectroscopy analysis as soon after receipt as possible. Distilled water is added when necessary to obtain a standardized counting geometry of 2 liters. Table 1 gives the gamma-ray efficiencies and detection limits for the gamma-ray spectrometer. After gamma-ray analysis, the samples are filtered through Whatman No. 42 filter paper. The filter paper containing the suspended solids is ashed in a muffle furnace, transferred to a tared planchet, weighed, and counted for gross beta radioactivity. The filtrate is evaporated to near dryness, quantitatively transferred to a tared planchet, dried, weighed, and counted for gross beta radioactivity.

Columbia River water is analyzed for gamma radioactivity approximately 14 days after collection. This delay allows the short-lived radionuclides, sodium–24, arsenic–76, and neptunium–239 to decay, leaving a less complex spectrum which can be evaluated without computer assistance. Following gamma radioanalysis, the Columbia River samples are divided into two aliquots for further analysis. One aliquot is prepared for phosphorus–32 analysis and the other is analyzed for gross beta radioactivity by the methods described above. Gross beta particle counting for all samples is performed 18 days after collection.

The phosphorus–32 analysis, a modification of published methods (*1–4*), begins 15 days after sample collection to allow arsenic–76 and other short–lived radionuclides to decay. The phosphorus is separated from interfering nuclides by precipitation as ammonium phos-

[1] Summarized from "Environmental Radiation Surveillance Quarterly Reports and Fifth Annual Report, December 1966."

Table 1. Beta-particle and gamma-ray efficiencies and detectability limits for the Washington State analyses

Radionuclide	Energy band (MeV)	Efficiency (percent)	Average background (cpm)	Detectability limits (pCi)
Beta				
Strontium-90-yttrium-90	–	34	0.5	[a] 0.31
Yttrium-90	–	38	.5	[a] .28
Phosphorus-32	–	35	.5	[a] .30
Gamma				
Chromium-51	0.30–0.36	0.52	23.18	[b] 200
Ruthenium-106	0.44–0.56	.91	22.36	[b] 100
Cesium-137	0.62–0.72	2.75	11.18	[b] 30
Zirconium-95	0.73–0.79	6.96	5.72	[b] 10
Zinc-65	1.05–1.17	1.06	6.38	[b] 40

[a] Amount of radiation necessary to produce a net cpm equal to 2 sigma of background, based on 100 minute counts.
[b] Amount of radiation necessary to produce a net cpm equal to 4 sigma of the respective background, based on 100 minute counts.

phomolybdate from an acid medium. The precipitate is washed with ammonium nitrate, dissolved with 3*N* ammonium hydroxide, transferred to a tared planchet, dried, ashed at 450° C., and counted for beta radioactivity.

Results

Table 2 presents the monthly average results for seven Columbia River stations which are sampled routinely. In averaging, a less-than value is assumed to be equal to its numerical value and a less-than sign is placed in front of the average.

Table 3 summarizes the beta radioactivity measurements from 35 other surface water stations from July 1966 through June 1967. The second column in this table gives code numbers and the abbreviations denoting geographical sections (figure 1). Each river is assigned a four digit number; the first two digits indicate the river and the second two digits indicate the sampling stations on the river. For example, code number 04 refers to the Snake River in the area designated "RSE", i.e., Southeast. The code number 01 refers to the first sampling station on that river. The third column gives the total number of samples analyzed. Gross beta radioactivity results are not extrapolated to the date of collection.

Table 4 lists six samples which showed gamma radioactivity ranging from eight cpm/liter to fourteen cpm/liter (the other 169 samples were all less than five cpm/liter). The two samples collected on January 4 and January 5, 1967 from the Puyallup River and the Snake River respectively showed definite fallout from the foreign nuclear detonation of December 24, 1966. The other four samples showing detectable gamma radioactivity could not be attributed to any single event.

The network summary gives the maximum and minimum values for the 175 samples analyzed, while the network average is obtained by averaging all the station average values.

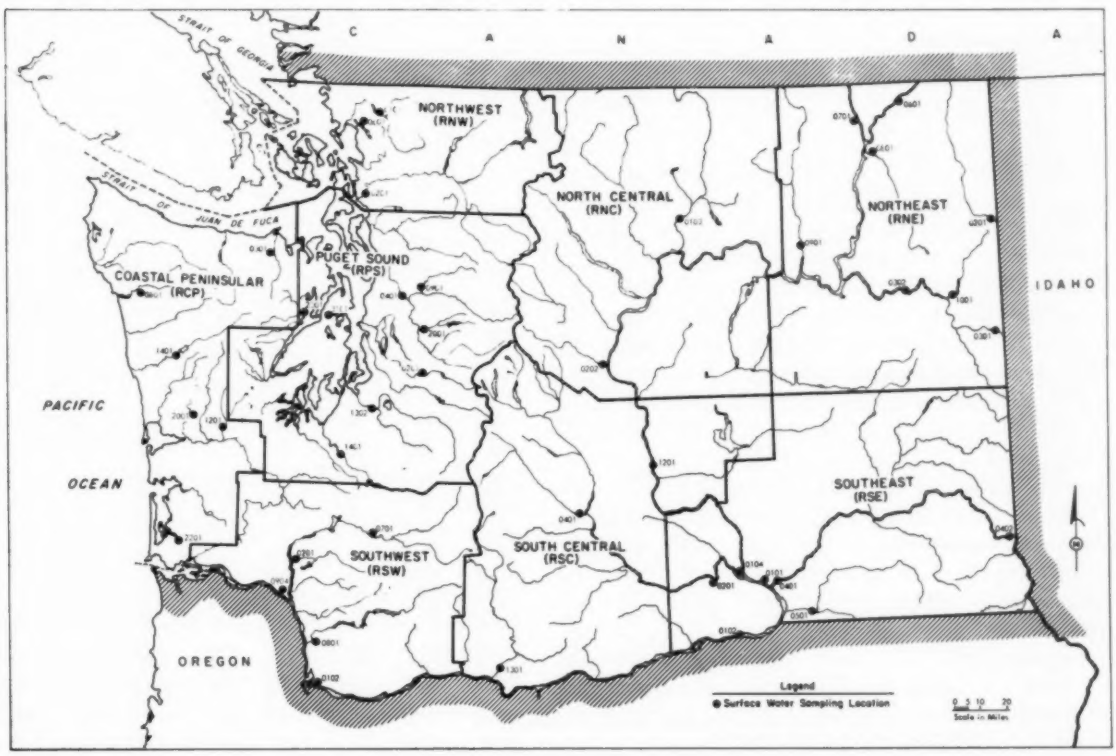

Figure 1. Washington surface water sampling locations with code numbers

Table 2. Monthly average radioactivity in Columbia River water, July 1966–June 1967

Location and type of analysis	Concentration (pCi/liter)											
	1966						1967					
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
McNary Dam (code No. RSE 0102)												
Beta-particle												
Suspended [a]	NS	NS	8	NS	NS	8	NS	14	NS	NS	11	NS
Dissolved [a]	NS	NS	30	NS	NS	70	NS	76	NS	NS	22	NS
Total [a]	NS	NS	38	NS	NS	78	NS	90	NS	NS	33	NS
Phosphorus-32 [b]	NS	NS	36	NS	NS	84	NS	103	NS	NS	25	NS
Gamma-ray [b]												
Chromium-51	NS	NS	2,091	NS	NS	2,935	NS	3,356	NS	NS	532	NS
Ruthenium-106 [c]	NS	NS	<50	NS	NS	<50	NS	67	NS	NS	<50	NS
Zirconium-95	NS	NS	<10	NS	NS	<10	NS	<5	NS	NS	<5	NS
Zinc-65	NS	NS	<25	NS	NS	115	NS	174	NS	NS	69	NS
Northport (code no. RNE 0601)												
Beta-particle												
Suspended [a]	NS	NS	<1	NS	NS	<1	NS	<1	NS	NS	NS	1
Dissolved [a]	NS	NS	3	NS	NS	3	NS	3	NS	NS	NS	3
Total [a]	NS	NS	<4	NS	NS	<4	NS	<4	NS	NS	NS	4
Phosphorus-32 [b]	NS	NS	<1	NS	NS	<1	NS	<1	NS	NS	NS	<1
Gamma-ray [b]												
Chromium-51	NS	NS	<100	NS	NS	<100	NS	<100	NS	NS	NS	<100
Ruthenium-106 [c]	NS	NS	<50	NS	NS	<50	NS	<50	NS	NS	NS	<50
Zirconium-95	NS	NS	<10	NS	NS	<10	NS	<5	NS	NS	NS	<5
Zinc-65	NS	NS	<25	NS	NS	<20	NS	<20	NS	NS	NS	<20
Richland (code no. RSE 0104)												
Beta-particle												
Suspended [a]	4	17	24	32	1	20	22	24	14	26	58	29
Dissolved [a]	30	15	121	164	61	195	211	150	222	282	242	62
Total [a]	34	32	145	196	62	215	233	174	236	308	300	91
Phosphorus-32 [b]	27	4	148	123	67	176	254	198	232	360	288	74
Gamma-ray [b]												
Chromium-51	<779	<200	5,740	8,458	3,914	8,197	7,322	7,681	6,472	7,284	5,652	1,539
Ruthenium-106 [c]	<100	<100	<100	<144	<100	<115	<100	<111	104	111	127	<100
Zirconium-95	<20	<20	<20	<20	<20	<20	<10	<10	<10	<10	<10	<10
Zinc-65	<75	143	173	278	100	299	382	408	339	466	445	198
Pasco (code no. RSE 0101)												
Beta-particle												
Suspended [a]	12	1	46	26	37	54	27	34	23	30	47	15
Dissolved [a]	40	5	99	86	51	123	117	170	108	144	103	26
Total [a]	52	6	145	112	88	177	144	204	131	174	150	41
Phosphorus-32 [b]	54	NA	95	61	20	113	147	201	121	183	219	29
Gamma-ray [b]												
Chromium-51	1,137	<100	6,733	5,027	4,550	6,118	3,592	6,875	4,918	3,777	4,678	815
Ruthenium-106 [c]	<50	<50	60	57	<50	<50	57	103	95	84	98	<50
Zirconium-95	<10	<10	<10	<10	<10	<10	<5	<5	<5	<5	<5	<5
Zinc-65	81	<25	149	114	157	191	242	348	282	273	343	90
Wanapum Dam (code no. RSC 1201)												
Beta-particle												
Suspended [a]	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dissolved [a]	2	3	3	3	3	3	3	3	3	3	2	3
Total [a]	<3	<4	<4	<4	<4	<4	<4	<4	<4	<4	<3	<4
Phosphorus-32 [b]	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Gamma-ray [b]												
Chromium-51	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Ruthenium-106 [c]	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Zirconium-95	<10	<10	<10	<10	<10	<10	<5	<5	<5	<5	<5	<5
Zinc-65	<25	<25	<25	<25	<20	<20	<20	<20	<20	<20	<20	<20
Vancouver (code no. RSW 0102)												
Beta-particle												
Suspended [a]	6	1	3	6	4	7	20	13	10	27	28	13
Dissolved [a]	10	4	12	24	26	30	34	32	35	41	44	19
Total [a]	16	5	15	30	30	37	54	45	45	68	72	32
Phosphorus-32 [b]	9	<1	5	21	26	35	38	34	38	44	56	21
Gamma-ray [b]												
Chromium-51	<332	<100	926	1,766	1,568	1,749	1,879	1,409	1,728	1,471	1,823	606
Ruthenium-106 [c]	<50	<50	<50	<50	<50	<50	<55	<50	<50	<50	<50	<51
Zirconium-95	<10	<10	<10	<10	<10	<10	<5	<5	<5	<5	<5	<5
Zinc-65	<37	<25	<25	<25	21	32	51	68	70	80	104	48
Longview (code no. RSW 0904)												
Beta-particle												
Suspended [a]	4	1	2	4	3	NS	5	3	5	7	12	5
Dissolved [a]	10	4	8	17	16	NS	15	8	15	17	20	11
Total [a]	14	5	10	21	19	NS	20	11	20	24	32	16
Phosphorus-32 [b]	9	<1	4	14	15	NS	15	8	15	20	23	12
Gamma-ray [b]												
Chromium-51	<460	<100	<617	1,090	1,211	NS	888	324	704	697	746	3[illegible]
Ruthenium-106 [c]	<50	<50	<50	<50	<50	NS	<50	<50	<50	<50	<50	<50
Zirconium-95	<10	<10	<10	<10	<10	NS	<5	<5	<5	<5	<5	<5
Zinc-65	<28	<25	<25	<25	<23	NS	<20	<20	33	36	53	22

[a] Activity at time of counting. Strontium-90-yttrium-90 calibration standard.
[b] Results extrapolated to date of sample collection.
[c] Net activity in the 0.44–0.56 MeV gamma-range is assumed to be only ruthenium-106.
NS, no sample reported.
NA, no analysis.

Table 3. Beta radioactivity in Washington surface water (except for Columbia River) July 1966–June 1967

Sampling location	Code number	Number of samples	Concentrations (pCi/liter)								
			Suspended			Dissolved			Total		
			Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum
Cedar River	RPS 0201	12	<1	<1	<1	<1	<1	1	1	1	2
Chico Creek	RPS 3101	1	<1			2			3		
Colville River	RNE 0801	2	1	<1	2	5	4	5	6	5	7
Cowlitz River	RSW 0701	1	<1			1			2		
Dosewallips River	RPS 2301	1	<1			<1			1		
Dungeness River	RCP 0301	1	<1			<1			1		
Hoh River	RCP 0801	1	<1			1			2		
Kettle River	RNE 0701	3	<1	<1	<1	2	2	2	3	3	3
Klickitat River	RCS 1301	8	<1	<1	1	2	1	2	3	2	3
Lake Whatcom	RNW 0601	11	<1	<1	2	3	2	4	4	3	5
Lewis River	RSW 0801	11	<1	<1	2	<1	<1	2	1	1	4
Little Spokane River	RNE 1001	2	<1	<1	<1	3	2	3	4	3	4
Naches River	RSC 0401	12	<1	<1	<1	1	<1	2	2	1	3
Naselle River	RCP 2201	11	<1	<1	2	<1	<1	1	1	1	3
Nisqually River	RPS 1401	4	<1	<1	1	2	<1	3	3	1	4
Nooksack River	RNW 0101	4	<1	<1	<1	1	1	2	2	2	3
Okanogan River	RNC 0103	5	1	<1	3	3	2	4	4	3	6
Pend Oreille River	RNE 0201	7	<1	<1	<1	2	2	3	3	3	4
Puyallup River	RPS 1302	11	2	<1	7	2	1	5	4	2	10
Quinault River	RCP 1401	1	<1			<1			1		
Sanpoil River	RNE 0901	1	<1			2			3		
Satsop River	RCP 1201	4	3	<1	10	<1	<1	1	4	1	11
Skagit River	RNW 0201	12	<1	<1	<1	2	1	3	3	2	4
Snake River	RSE 0401	3	1	<1	2	4	2	5	5	4	6
	RSE 0402	4	5	<1	17	6	3	9	11	5	26
Snohomish River	RPS 0401	4	<1	<1	<1	1	1	2	2	2	3
Spokane River	RNE 0301	1	<1			1			2		
	RNE 0302	3	<1	<1	<1	3	2	4	4	3	5
Sultan River	RPS 0901	3	<1	<1	<1	2	2	2	3	3	3
Tolt River	RPS 2001	4	<1	<1	<1	1	1	1	2	2	2
Toutle River	RSW 0201	4	<1	<1	<1	1	1	[b] 2	2	2	3
Walla Walla River	RSE 0501	3	2	1	3	5	3	10	7	5	11
Wenatchee River	RNC 0202	5	<1	<1	<1	2	2	2	3	3	3
Wishkah River	RCP 2001	10	<1	<1	<1	<1	<1	1	1	1	2
Yakima River	RCS 0201	5	<1	<1	<1	<1	<1	1	1	1	2
Network summary		175	<1	<1	17	1.8	<1	10	3.0	1	26

[a] For averaging purposes, <1 is assumed to be equal to 0.5 pCi/liter. Averages less than 1 are recorded as <1.
[b] One analysis voided, not included in average.

Discussion

Of the 175 river water samples analyzed from July 1966 through June 1967 (excluding the Columbia River) the total beta radioactivity ranged from 1 to 26 pCi/liter with an average of 3.0 pCi/liter. The radioactivity of the suspended fraction ranged from <1 to 17 pCi/liter with an average of <1 pCi/liter. The radioactivity of the soluble fraction was approximately the same, ranging from <1 to 10 pCi/liter and averaging 1.8 pCi/liter. These network averages during the July 1966 through June 1967 period were lower than the averages for the preceding 12 months.

Monthly average total beta radioactivity for the Columbia River stations below the Hanford facility ranged from 5 to 308 pCi/liter. Monthly average concentrations of the beta-particle emitter, phosphorus–32, in the Columbia River water samples taken below the Hanford facility ranged from <1 to 360 pCi/liter.

The gamma-ray emitters, ruthenium–106 and zirconium–95, were found in monthly average concentrations that ranged from <50 to 127 pCi/liter for ruthenium–106 and <5 to <20 pCi/liter for zirconium–95. The values for ruthenium–106 were probably a combination of ruthenium–103 and ruthenium–106. Two other radionuclides, chromium–51 and zinc–65, were found in detectable quantities in Columbia River water. Monthly averages for chromium–51 ranged from <100 to 8,458 pCi/liter, and for zinc–65 the range was <20 to 466 pCi/liter.

Although any standards for gross beta radioactivity must be very carefully applied, the standard for drinking water is 1,000 pCi/liter of gross beta radioactivity in the absence of strontium–90 and alpha emitters (*5*). The standards for water from all dietary sources for the general population at large (*6*) are:

chromium–51, 670,000 pCi/liter; ruthenium–106, 3,300 pCi/liter; zinc–65, 10,000 pCi/liter; and phosphorus–32, 7,000 pCi/liter.

Table 4. Gamma radioactivity in Washington surface water

Date	Location	(cpm/liter)
9/24/66	Little Spokane River	8
1/4/67	Puyallup River	7
1/5/67	Snake River	14
4/23/67	Pend Oreille River	12
4/24/67	Cedar River	9
5/22/67	Cedar River	10

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July 1964–June 1965	May 1966
July 1965–June 1966	August 1967

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Drinking Water Analysis Program, 1961–1966[1]

Water Supply and Sea Resources Program
National Center for Urban and Industrial Health and *National Center for Radiological Health*

The routine surveillance of finished drinking water from public drinking water supplies has been a project of the Public Health Service's Water Supply and Sea Resources Program[2] since 1960. Since that time over three hundred community water supplies have been examined for selected parameters of radioactivity. The basic network for this activity is the approximately 800 water supplies (serving over half of the nations population with access to public water systems) which provide water for use by Interstate Carrier Companies. These water supplies are subject to the provisions of Subpart J of the Interstate Quarantine Regulation most commonly referred to as the Public Health Service drinking water standards. The project for surveillance of the radioactivity levels has been incorporated into the normal survey activities associated with application of the drinking water standards. Laboratory support is provided by the Northeastern, Southeastern and Southwestern Radiological Health Laboratories of the National Center for Radiological Health. Sampling has been conducted as a secondary part of the overall application of the standards and has not been by nationwide design. For the most part, samples have been composited over a fourteen day period taking 90 milliliters, three times during the operating day; however, as indicated in table 1, many samples have also been taken at one point in time. In many cases where a water system receives raw water from more than one source the finished drinking water derived from each source has been examined.

[1] Summarized from "Drinking Water Quality of Selected Interstate Carrier Water Supplies, 1962–1963," U.S. Public Health Service, PHS Publication No. 1049–A.

[2] Formerly Water Supply Section, Division of Environmental Engineering and Food Protection.

Table 1. Occurrence of radioactivity concentrations in finished drinking water (pCi/liter) 1961–1966

Sampling location		Sampling periods	Strontium-90 in total solids	Alpha radioactivity		Beta radioactivity	
				Dissolved	Suspended	Dissolved	Suspended
Ala:	Birmingham	10/4–10/18/61	—	—	—	3.7	<3.0
		5/4–5/19/62	—	—	—	8.8	<3.0
		10/4–10/18/61	—	—	—	<3.0	<3.0
		5/2–5/18/62	—	—	—	5.2	<3.0
	Gadsden	9/25–10/10/61	1.8	—	—	3.4	<3.0
		3/14–3/28/62	—	—	—	14.0	<3.0
	Mobile	11/16–12/2/61	—	—	—	6.3	<3.0
		5/1–5/15/62	—	—	—	14.0	<3.0
	Montgomery	5/30–6/13/61	—	<.5	<.5	<3.0	<3.0
		5/31–6/15/61	—	<.5	<.5	<3.0	<3.0
	Stevenson	6/7–6/22/61	1.1	—	—	37.0	<3.0
	Tuscaloosa	5/20–6/6/65	—	0.0	0.0	3.1	<3.0
Alaska:	Kodiak	4/5–4/18/65	—	<.1	<.1	<1.0	5.0
Ariz:	Phoenix	7/25–8/8/61	—	<.5	<.5	<1.0	<1.0
		7/25–8/8/61	—	<.5	<.5	<6.6	<1.0
		7/25–8/8/61	—	<.5	<.5	6.3	<1.0
		7/25–8/8/61	—	1.5	<.5	5.2	<1.0
		7/25–8/8/61	—	<.5	<.5	6.2	<1.0
	Tucson	6/8–6/21/61	—	3.5	<.5	5.0	<1.0
Calif:	Fresno	10/2–10/18/61	—	—	—	3.5	2.3
	Needles	7/18–8/4/61	—	<.5	<.5	8.2	<1.0
Colo:	Durango	6/8–6/22/65	—	0.8	0.2	3.0	<1.0
Conn:	Groton	9/24–9/28/66	—	—	—	—	—
	Hartford	4/26–5/10/61	—	<5.0	<5.0	<3.0	<3.0
		12/5–12/18/62	<1.0	<1.0	<1.0	4.0	1.0
	New Haven	2/25–3/11/62	—	<1.0	<1.0	5.0	<1.0
	New London	9/15–9/30/66	—	—	—	—	—
	Waterbury	—	—	<1.0	<1.0	5.0	<1.0
Del:	Clayton		10.0	2.6	<1.0	13.0	2.0
	Lewes	6/19–6/23/64	<1.0	<1.0	<1.0	<1.0	<1.0
	Wilmington	1965	—	<1.0	<1.0	3.0	<1.0
	Brandywine	2/13–3/1/61	—	<.5	—	<2.6	—
		11/7–11/21/61	—	—	—	7.2	<3.0
		9/11–9/24/62	<1.0	<1.0	<1.0	3.0	<1.0
		10/2–10/15/62	<1.0	<1.0	<1.0	5.0	<1.0
D. C:	Washington	11/18/66	1.5	<.2	<.2	4.0	<3.0
		10/11–10/26/61	—	—	—	7.5	<3.0
		10/11–10/28/61	—	—	—	6.1	<3.0
Fla:	Ft. Lauderdale	4/27–5/11/61	—	<.5	<.5	5.4	<3.0
		9/19–10/9/62	—	—	—	3.0	3.0
		4/27–5/12/61	—	<.5	<.5	<3.0	<3.0
		9/19–10/3/62	—	—	—	<3.0	<3.0
Ga:	Atlanta		—	<.3	<.3	7.3	<3.0
		8/15–9/1/61	—	—	—	<3.0	<3.0
		3/13–3/29/62	—	—	—	7.9	<3.0
		8/15–8/30/61	—	—	—	<3.0	<3.0
		12/17–1/2/63	—	—	—	8.8	<3.0
	Columbus	11/14–11/28/61	—	—	—	4.5	<3.0
		1/10–1/28/63	—	—	—	11.8	<3.0
	Savannah	11/28–12/14/61	—	—	—	13.0	<3.0
		8/2–8/16/62	—	—	—	5.9	3.0
		8/2–8/16/62	—	—	—	<3.0	<3.0
Ill:	Alton	5/19–6/2/66	—	<1.0	<1.0	8.0	<1.0
	Beardstown	3/24–4/6/64	<1.0	<1.0	<1.0	2.0	<1.0
	Cairo	2/16–3/13/61	0.3	12.0	—	2.6	—
		6/29–7/13/62	<1.0	<1.0	<1.0	<1.0	<1.0
	Chester	2/15–3/2/61	0.7	<.5	—	3.6	—
	Danville	9/15–9/29/64	—	1.0	<1.0	6.0	<1.0
	Decatur	7/11–7/26/61	—	—	—	<3.0	<3.0
		5/20–6/4/66	—	<1.0	<1.0	5.0	<1.0
	E. St. Louis	2/14–2/28/61	0.9	<.5	—	3.3	—
	Joliet	10/12–10/25/66	0.0	3.0	<1.0	10.0	<1.0
	Lockport	10/20–11/3/64	—	4.0	<1.0	3.0	<1.0
	Moline Airport	9/23–10/6/64	—	<1.0	<1.0	4.0	<1.0
	Orland Park	1965	—	<1.0	<1.0	3.0	<1.0
	Peoria	6/28–7/12/66	2.0	<1.0	<1.0	11.0	<1.0
	Peru	9/26–11/8/65	2.0	3.0	<1.0	18.0	<1.0
	Quincy Airport	1964	<1.0	<1.0	<1.0	2.0	<1.0
	Rockford	1965	—	<1.0	<1.0	2.0	<1.0
	Rock Island	7/12–7/26/61	—	<.5	<.5	3.6	<3.0
	Springfield	5/4–5/18/65	—	4.0	3.0	<1.0	<1.0
	Wood River	5/27–6/8/66	—	1.0	<1.0	3.0	<1.0
Ind:	Elkhart	6/16–6/30/61	—	<.5	<.5	<3.0	<3.0
		2/19–3/5/62	—	—	—	<3.0	<3.0
	Evansville	6/15–6/30/61	—	<.5	<.5	<3.0	<3.0
		8/6–8/21/62	<1.0	<1.0	<1.0	4.0	<1.0
	Indianapolis	12/13–12/27/66	—	<1.0	<1.0	5.0	<1.0
	White River	1/17–2/1/61	0.3	<.5	<.5	3.2	<2.6
		5/16–5/30/62	—	—	—	12.1	<3.0

Table 1. Continued.

Sampling location		Sampling periods	Strontium-90 in total solids	Alpha radioactivity		Beta radioactivity	
				Dissolved	Suspended	Dissolved	Suspended
	Fall Creek	1/17–2/1/61	0.3	<.5	<.5	<2.6	<2.6
		5/14–5/29/62	—	—	—	15.0	<3.0
	Lafayette	—	—	1.0	<1.0	4.0	<1.0
	Muncie	1/18–2/1/61	0.2	<.5	<.5	<2.6	<2.6
		5/24–6/7/62	—	—	—	19.0	<3.0
	Washington	6/13–6/21/61	—	<.5	<.5	<3.0	<3.0
		8/6–8/20/62	<1.0	0.0	0.1	0.1	0.0
		5/3–5/17/66	—	<1.0	<1.0	1.0	<1.0
Iowa:	Burlington	1/4–1/18/62	—	1.0	—	9.3	.3
	Des Moines	11/1–11/17/61	—	—	11.4	—	—
Kans:	Kansas City	11/2–11/20/61	—	6.5	.1	.6	3.6
Ky:	Ashland	—	—	<.1	<.1	<14.3	3.0
		1/26–2/9/61	.1	<.5	—	<2.6	—
	Lexington Main plant	1/23–2/7/61	—	<.5	—	<2.6	—
		2/19–3/4/64	—	<.1	<.1	6.2	<3.0
	Lexington River station	2/19–3/4/64	4.2	<.1	<.1	14.7	<3.0
	Louisville	6/14–6/28/61	—	<.5	<.5	3.2	<3.0
	Paducah	11/2–11/17/66	—	—	—	6.8	<1.0
		3/7–3/21/62	—	—	—	22.0	<3.0
La:	Alexandria	8/8–8/21/61	—	—	—	<3.0	<3.0
		10/24–11/14/62	—	—	—	5.1	<3.0
	Baton Rouge	8/9–8/31/61	—	—	—	<3.0	<3.0
		9/20–10/30/62	—	—	—	9.4	3.0
	New Orleans	—	—	—	—	—	—
	Carrolton	11/6–11/20/62	—	—	—	7.2	<3.0
		8/10–8/24/61	—	—	—	3.9	<3.0
	Shreveport	8/17–8/25–61	—	—	—	4.0	<3.0
		9/20–10/16/62	—	—	—	<3.0	<3.0
		8/7–8/25/61	—	—	—	4.4	<3.0
		9/21–10/8/62	—	—	—	8.8	<3.0
Maine:	Bar Harbor	5/15–5/29/64	5.0	<1.0	<1.0	18.0	3.0
	Portland	3/20–4/3/61	—	<.5	<.5	3.9	<3.0
		10/10–10/24/62	<1.0	<1.0	<1.0	7.0	<1.0
		-7/7/66	2.0	<1.0	<1.0	12.0	2.0
	Searsport	5/14–5/28/64	3.0	<1.0	<1.0	12.0	7.0
	Wiscasset	3/15–3/29/65	—	<1.0	<1.0	2.0	<1.0
Md:	Baltimore	10/30–11/13/61	—	—	—	4.6	<3.0
		6/13–6/26/63	—	—	—	8.7	<3.0
		10/27–11/10/61	—	—	—	6.8	<3.0
	Hagerstown	10/9–10/25/61	—	—	—	6.0	<3.0
		5/15–5/28/62	—	—	—	10.0	<3.0
		5/14–5/29/62	—	—	—	5.8	<3.0
Mass:	Fall River:	11/23–12/7/64	—	2.0	<1.0	7.0	2.0
	Lowell	3/16–3/30/61	—	<.5	<.5	<3.0	<3.0
		2/5–2/18/63	<1.0	<1.0	<1.0	3.0	<1.0
	Springfield	6/22–7/6/64	1.5	<1.0	<1.0	11.0	<1.0
	Worchestor	4/14–4/28/65	—	<1.0	<1.0	3.0	<1.0
Mich:	Ann Arbor	4/20–5/6/61	—	<.5	<.5	<3.0	<3.0
		9/10–10/3/62	<1.0	<1.0	<1.0	3.0	<1.0
	Bay City	9/14–9/29/61	—	—	—	4.4	<3.0
		4/4–4/20/62	2.4	—	—	16.0	<3.0
	Calumet	—	—	1.0	<1.0	3.0	<1.0
	Detroit:						
	Park	7/29–8/12/64	—	<1.0	<1.0	3.0	5.0
	Northeast	8/3–8/17/64	—	<1.0	<1.0	4.0	<1.0
	Southwest	8/18–8/31/64	—	<1.0	<1.0	6.0	2.0
	Spring	—	—	—	—	—	—
	Wells	8/19–9/2/64	—	<1.0	<1.0	3.0	<1.0
	East China	6/17–6/30/66	—	<1.0	<1.0	5.0	<1.0
	Habor Springs	6/20–7/3/66	—	<1.0	<1.0	1.0	<1.0
	Freeland	6/16–6/30/66	—	2.0	<1.0	1.0	<1.0
	Houghton	—	—	<1.0	<1.0	<1.0	<1.0
	Ishpeming	—	—	<1.0	<1.0	8.0	<1.0
	Mackinac	6/27–7/10/66	—	<1.0	<1.0	<1.0	2.0
	Monroe	4/19–5/3/61	—	<.5	<.5	4.6	<3.0
		9/17–10/2/62	<1.0	<1.0	<1.0	3.0	<1.0
	Muskegon	9/12–9/27/61	—	—	—	7.6	<3.0
		4/6–4/23/62	<1.0	—	—	7.3	<3.0
	Port Huron	4/21–5/5/61	—	<.5	<.5	2.9	<3.0
		9/17–9/30/62	<1.0	<1.0	<1.0	4.0	2.0
	Saginaw	10/24–11/7/66	—	<1.0	<1.0	5.0	2.0
	Saulte Ste Marie	9/13–9/29/61	—	—	—	5.4	<3.0
	Traverse	6/28–7/11/66	—	<1.0	<1.0	4.0	<1.0
	Wyandotte	8/26–9/9/64	—	<1.0	<1.0	4.0	<1.0
	Ypsilanti	8/27–9/9/64	—	<1.0	<1.0	3.0	<1.0
Minn:	Duluth	7/21–8/11/61	—	<.5	<.5	2.0	<1.0
Miss:	Greenville	1/12–1/27/61	.5	<.5	<.5	<2.6	<2.6
		10/25–11/9/62	—	—	—	<3.0	<3.0
	Jackson	6/1–6/15/61	—	<.5	<.5	<3.0	<3.0
	Vicksburg	2/15–3/2/61	.6	<.5	—	4.3	—
		8/13–8/28/62	—	—	—	11.4	<3.0

Table 1. Continued.

Sampling location		Sampling periods	Strontium-90 in total solids	Alpha radioactivity		Beta radioactivity	
				Dissolved	Suspended	Dissolved	Suspended
Mont:	E. Glacier	1965	—	<.1	<.1	2.0	<1.0
	Havre	1965	—	.3	.1	13.0	<1.0
Nebr.	Lincoln	10/24–11/8/61	—	—	—	18.6	1.2
	N. Platte	10/24–11/7/61	—	11.4	.3	14.1	.3
N. H:	Berlin	5/1–5/13/61	—	<.5	<.5	<1.0	<3.0
		10/15–10/30/62	<1.0	<1.0	<1.0	6.0	<1.0
	Manchester	5/3–5/17/61	—	<.5	<.5	4.4	<3.0
		10/20–11/2/62	<1.0	<1.0	<1.0	8.0	1.0
		6/1–6/14/66	—	<1.0	<1.0	12.0	<1.0
N. J:	Atlantic City	7/15–7/29/64	—	<1.0	<1.0	5.0	2.0
	Elizabethtown Water Co	5/13–5/27/65	1.0	<1.0	7.0	2.0	35.0
	Hackensack Water Co	9/4–9/18/64	—	<1.0	<1.0	<1.0	1.0
	Jersey City	10/26–11/2/64	—	5.0	<1.0	7.0	<1.0
	Newark	10/23–11/6/64	—	<1.0	<1.0	6.0	<1.0
	Ocean City	9/1–9/14/64	—	<1.0	<1.0	2.0	<1.0
	Trenton	10/2–10/16/61	—	—	—	10.0	<3.0
		10/10–10/25/62	<1.0	<1.0	<1.0	4.0	<1.0
	Wanaque	1964	—	2.0	<1.0	2.0	<1.0
N. Mex:	Albuquerque	6/6–6/21/61	—	2.2	<.5	4.8	<1.0
		8/2–8/17/62	—	—	—	<3.0	3.3
	Farmington	8/6–8/21/62	—	—	—	4.8	<3.0
		6/7–7/25/61	—	.1	.2	10.0	<1.0
N. Y:	Albany	9/27–10/5/61	—	—	—	<3.0	<3.0
		3/27–4/9/62	2.0	—	—	14.0	<3.0
	Buffalo	9/29–10/13/61	—	—	—	3.8	<3.0
		9/4–9/18/62	<1.0	.0	.1	3.8	.4
		5/10–5/21/65	—	<1.0	<1.0	5.0	<1.0
	Croton	11/14–11/29/61	—	—	—	11.0	8.0
	Catskill	10/24–11/8/61	—	—	—	3.7	<3.0
	Jamaica	10/16–11/3/61	—	—	—	3.4	<3.0
	Woodhaven Water Co	10/30–11/14/61	—	—	—	3.2	<3.0
		2/2–2/19/62	—	—	—	<3.0	<3.0
	Poughkeepsie	9/12–9/26/61	—	—	—	3.4	<3.0
		—	<1.0	<1.0	<1.0	8.0	<1.0
		2/16–3/4/65	—	2.0	<1.0	6.0	<1.0
	Rensselaer	9/17–10/1/63	—	<1.0	<1.0	5.0	<1.0
	Rochester	9/13–9/27/61	3.3	—	—	3.7	<3.0
		8/29–9/12/62	<1.0	<1.0	<1.0	6.0	4.0
		9/13–9/26/61	—	—	—	5.4	<3.0
		8/30–9/13/62	<1.0	.1	.1	2.2	4.8
		9/14–9/27/61	<1.0	—	—	4.6	<3.0
		8/30–9/15/62	<1.0	<1.0	<1.0	1.0	<1.0
	Schenectady	9/28–10/10/61	—	—	—	<3.0	—
		3/22–4/5/62	—	—	—	<3.0	<3.0
	Troy	9/27–10/12/61	—	—	—	<3.0	<3.0
		4/11–4/28/62	<1.0	—	—	18.0	4.0
	White Plains	9/11–9/23/64	—	<1.0	<1.0	4.0	<1.0
	Yonkers:						
	Grassy Spring Supply	11/5–12/15/64	2.0	2.0	<1.0	19.0	2.0
	Saw Mill Supply	11/6–11/20/64	4.0	<1.0	<1.0	11.0	<1.0
N. C:	Charlotte	3/30–4/14/61	<1.0	<.5	<.5	<3.0	<3.0
		3/30–4/14/61	<1.0	<.5	<.5	<3.0	<3.0
	Fayetteville	—	—	<3.0	<3.0	<3.0	<3.0
	Raleigh	4/10–4/24/61	<1.0	<.5	<.5	<3.0	<3.0
		3/22–4/5/62	1.6	—	—	19.0	<3.0
	Winston-Salem	2/14–3/1/61	.2	<.5	—	<2.6	—
N. Dak:	Bismarck	7/18–8/5/61	—	<.5	<.5	6.6	<1.0
	Grand Forks	11/9–12/1/61	—	6.4	1.1	12.5	.8
	Williston	8/29–9/13/61	—	14.4	1.1	12.8	.7
Ohio:	Akron	8/18–9/1/61	—	—	—	<3.0	3.6
		2/19–3/4/62	—	—	—	15.0	<3.0
		5/19–5/24/65	—	<1.0	4.0	4.0	<1.0
	Cincinnati	3/13–3/29/61	—	<.5	<.5	<3.0	<3.0
		8/6–8/20/62	<1.0	<1.0	<1.0	<5.0	<1.0
		4/18–5/1/66	—	2.0	<1.0	5.0	<1.0
	Cleveland	1965	—	<1.0	<1.0	4.0	<1.0
	Columbus	4/18–5/2/66	—	<1.0	<1.0	4.0	1.0
	Crestline	7/7–7/20/64	<1.0	<1.0	<1.0	1.0	<1.0
	Huron	5/27–6/10/64	<1.1	<1.0	<1.0	3.0	<1.0
	Lima	3/16–3/30/61	—	<.5	<.5	4.6	<3.0
		8/6–8/20/62	<1.0	<1.0	<1.0	5.4	<1.0
	Lorain	5/10–5/24/65	—	<1.0	2.0	4.0	<1.0
	Marion	7/9–7/23/65	<1.0	<1.0	<1.0	7.0	<1.0
	Mt. Vernon	—	<1.0	<1.0	<1.0	7.0	<1.0
	Sandusky	5/26–6/9/64	<1.0	<1.0	<1.0	8.0	<1.0
	Springfield	3/15–3/30/61	—	<.5	<.5	<3.0	<3.0
		8/6–8/20/62	<1.0	.0	.1	.8	.6
	Toledo	8/17–9/3/61	—	—	—	<3.0	<3.0
		2/19–3/7/62	—	—	—	8.1	3.0
		4/19–5/3/66	—	<1.0	<1.0	3.0	1.0
	Wellsville	7/9–7/28/64	<1.0	<1.0	<1.0	4.0	1.0
	Willard	9/26–10/13/66	—	1.0	<1.0	1.0	<1.0
	Youngstown	7/9–7/25/64	5.0	<1.0	<1.0	10.0	<1.0

Table 1. Continued.

Sampling location		Sampling periods	Strontium-90 in total solids	Alpha radioactivity		Beta radioactivity	
				Dissolved	Suspended	Dissolved	Suspended
Okla:	Ardmore	2/8-2/23/61	0.7	<.5	—	<2.6	—
	Oklahoma City	5/25-6/8/61	—	<.5	<.5	6.2	<3.0
		2/9-2/25/61	1.2	6.0	—	5.7	—
		5/3-5/17/62	—	—	—	12.0	<3.0
		4/26-5/14/62	—	—	—	12.0	<3.0
Ore:	Astoria	10/26-11/9/64	—	3.1	10.3	3.0	<1.0
	Bend	7/29-8/9/64	—	.5	<.1	<1.0	<1.0
	Coos Bay	11/10-11/24/64	—	.7	.3	6.0	<1.0
	Eugene	10/24-11/9/61	—	—	—	1.4	—
		7/24-8/5/64	—	<.1	<.1	4.0	<1.0
	Florence	7/17-7/29/64	—	.1	.1	9.0	<1.0
	Klamath Falls	7/28-8/11/64	—	.1	.1	2.0	<1.0
	Medford	7/30-8/13/64	—	.6	<.1	1.0	<1.0
	Newport	7/17-7/31/64	—	<.1	.1	<1.0	<1.0
	Portland	7/22-8/4/64	—	<.1	1.3	<1.0	1.0
	Rainier	7/21-8/3/64	—	.8	.1	3.0	<1.0
Pa:	Allentown	6/10-6/15/61	—	<.5	<.5	<3.0	<3.0
		11/28-12/12/62	<1.0	<1.0	<1.0	1.0	<1.0
	Bethlehem	7/5-7/19/66	—	<1.0	<1.0	4.0	3.0
	Brownsville	3/25-4/5/65	—	<1.0	<1.0	2.0	<1.0
	Charleroi	3/24-4/6/65	—	<1.0	<1.0	2.0	<1.0
	Coraopolis	3/24-4/5/65	—	<1.0	<1.0	<1.0	<1.0
	Elizabeth	3/22-4/5/65	—	<1.0	<1.0	1.0	<1.0
	Harrisburg	7/13-7/24/66	—	<1.0	<1.0	1.0	<1.0
	Lancaster	7/13-7/27/61	—	—	—	3.3	<3.0
		1/7-1/22/63	<1.0	<1.0	<1.0	9.0	<1.0
		8/29-9/12/61	—	—	—	<3.0	<3.0
	Philadelphia	8/9-8/25/61	—	—	—	3.1	<3.0
		12/21-1/6/62	—	—	—	11.0	<3.0
		7/25-8/9/61	—	—	—	5.6	<3.0
		12/21-1/4/62	—	—	—	14.0	<3.0
		8/7-8/23/61	—	—	—	<3.0	<3.0
		12/21-1/6/62	—	—	—	13.0	<3.0
		1/30-2/14/61	—	—	<.5	<2.6	—
		12/26-1/4/62	—	—	—	11.0	<3.0
	Pittsburgh	3/23-4/5/65	—	<1.0	<1.0	4.0	1.0
	Reading	-7/29/66	—	<1.0	<1.0	6.0	<1.0
	Sayre	6/2-6/16/61	—	<.5	<.5	<3.0	<3.0
		9/4-9/22/62	<1.0	<1.0	<1.0	<3.0	<1.0
Puerto Rico:	San Juan	3/15-4/5/62	2.2	—	—	10.0	<3.0
		3/14-3/28/62	1.1	—	—	7.3	<3.0
R. I:	E. Providence Water Treatment Plant Well #1	11/13-11/25/64	—	3.0	<1.0	7.0	<1.0
		11/13-11/30/64	—	<1.0	<1.0	1.0	<1.0
	Providence	3/27-4/10/61	—	—	—	<3.0	—
		4/21-5/5/66	—	<1.0	<1.0	4.0	<1.0
S. C:	Charleston	1/10-1/25/61	—	—	—	<3.0	<3.0
		2/11-2/26/63	—	—	—	14.8	<1.0
	Greenville	2/16-3/3/61	0.2	<.5	—	<3.0	—
		2/7-2/22/63	—	—	—	9.6	3.2
	N. Augusta	9/4-9/17/61	—	—	—	<3.0	<3.0
S. Dak:	Aberdeen	8/28-9/12/61	—	—	9.4	15.3	3.8
	Sioux Falls	9/1-9/15/61	—	19.9	8.9	9.1	.1
		2/21-3/9/62	—	—	—	8.0	1.0
Tenn:	Chattanooga	7/12-7/28/61	3.2	—	—	45.0	<3.0
		1/25-2/12/62	—	—	—	14.0	<3.0
	Clarksville	7/6-7/24/61	—	<.5	<.5	<3.0	<3.0
		2/3-2/18/62	—	—	—	8.4	<3.0
	Knoxville	8/18-9/1/61	—	—	—	<3.0	<3.0
		2/6-2/20/62	—	—	—	7.8	<3.0
	Nashville		—	<.5	<.5	6.7	<3.0
Tex:	Austin Filter Plant #2	2/25-3/10/64	<.5	<.1	<.1	11.8	<3.0
	Brown Co	4/24-5/9/61	<1.0	<.5	<.5	7.0	<3.0
		1/15-1/31/62	—	—	—	11.1	<3.0
	Brownsville	3/30-4/13/61	—	<.5	<.5	5.0	<3.0
		3/9-3/23/62	—	—	—	5.3	<3.0
		3/29-4/12/61	<1.0	<.5	<.5	3.1	<3.0
		3/9-3/23/62	—	—	—	8.6	<3.0
	Corpus Christi	3/28-4/13/61	—	<.5	<.5	5.6	<3.0
		4/5-4/19/61	<1.0	<.5	<.5	6.2	<3.0
	Dallas	8/18-9/3/64	4.4	—	—	11.0	<3.0
	Denison		6.2	<.1	<.1	33.4	<3.0
	Galena Park		—	<.3	<.3	3.2	<3.0
			—	<.3	<.3	<3.0	<3.0
			—	<.3	<.3	<3.0	<3.0
			—	<.3	<.3	4.2	<3.0
	Galveston	7/18-8/3/61	—	—	—	<3.0	<3.0
	Port of Houston		—	<.3	<.3	<3.0	<3.0
	Laredo	4/26-5/25/61	—	<.5	<.5	4.3	<3.0
		3/1-3/16/62	—	—	—	19.0	<3.0
	Lubbock	2/28-3/16/61	—	<.5	<.5	12.8	<3.0
	Marshall	1964	6.0	—	—	15.0	<3.0
	Palestine (MoPac R. R.)	1964	—	<.1	<.1	<9.0	<3.0

Table 1. Continued.

	Sampling location	Sampling periods	Strontium-90 in total solids	Alpha radioactivity		Beta radioactivity	
				Dissolved	Suspended	Dissolved	Suspended
	Port Arthur	7/19–8/2/61	—	—	—	3.5	<3.0
		6/14–6/18/62	—	—	—	35.0	<3.0
	Port Isabel	4/16–4/30/64	5.8	1.2	<.1	29.5	<3.0
	San Angelo	4/25–5/9/61	—	<.5	<.5	<3.0	<3.0
		5/25–6/9/62	—	—	—	16.0	<3.0
	San Antonio	2/21–3/10/61	—	<.5	<.5	<3.0	<3.0
	Texarkana		6.0	—	—	16.0	3.0
	Waco	5/25–6/9/61	—	<.5	<.5	3.5	<3.0
		5/30/6/14/62	—	—	—	21.0	<3.0
	Wichita Falls	5/26–6/10/61	—	<.5	<.5	3.5	<3.0
		5/29–6/13/62	—	—	—	15.0	<3.0
Vt:	Burlington	1/11–1/25/61	1.9	<.5	<.5	2.9	<2.6
		12/11–12/29/62	<1.0	<1.0	<1.0	5.0	1.0
	St. Albans	12/8–12/22/64	—	<1.0	<1.0	9.0	<1.0
Va:	Norfolk	5/15–5/29/61	—	<.5	<.5	3.5	<3.0
		4/9–4/25/62	—	—	—	21.0	<3.0
		5/16–5/30/61	—	<.5	<.5	<3.0	<3.0
		4/9–4/24/62	1.3	—	—	20.0	<3.0
	Portsmouth	8/21–9/7/61	—	—	—	10.0	35.0
		3/1–3/17/62	—	—	—	5.1	<3.0
	Richmond	12/6–12/21/61	—	—	—	10.0	<3.0
		4/18–5/3/63	—	—	—	8.1	<1.0
Wash:	Spokane	7/26–8/10/61	—	<.5	<.5	5.7	2.3
W. Va:	Huntington	12/9–12/27/60	.7	—	—	2.2	<1.0
		6/7–6/22/62	—	—	—	6.8	<3.0
	Pt. Pleasant	8/65	2.4	<.2	<.2	3.3	<3.0
	Williamson	8/65	1.0	<.2	<.2	5.5	<3.0
Wisc:	Greenbay	5/16–6/3/61	—	<.5	<.5	<3.0	<3.0
		9/17–10/2/62	<1.0	<1.0	<1.0	3.0	<1.0
		7/19–8/2/66	—	<1.0	<1.0	5.0	<1.0
	La Crosse	11/24–12/8/64	—	3.0	<1.0	2.0	5.0
	Madison	7/18–8/1/61	—	—	—	3.8	<3.0
	Manitowoc	5/17–5/31/61	—	<.5	<.5	<3.0	<3.0
		11/5–11/23/62	<1.0	<1.0	<1.0	2.0	<1.0
	Milwaukee	6/10–6/25/64	<1.0	<1.0	<1.0	6.0	<1.0
		6/11–6/25/64	<1.0	<1.0	<1.0	4.0	<1.0
	Neenah	5/18–6/3/61	—	<.5	<.5	2.9	<3.0
		10/19–11/1/62	—	<1.0	<1.0	5.0	<1.0
	Wausau	6/9–6/23/64	<1.0	<1.0	<1.0	<1.0	<1.0

The drinking water standards for radionuclides are conservative in their requirements so that the total intake of these nuclides from all sources is not likely to result in an intake greater than the guidance levels given by the Federal Radiation Council (*2*).

The standards provide for the approval of water supplies, based on their radionuclide content, when the water does not contain more than 3 pCi/liter of radium–226 or 10 pCi/liter of strontium–90. In the absence of strontium–90 (much less than 10 pCi/liter), and in the absence of alpha emitters (much less than 3 pCi/liter), the water supply is acceptable when the gross beta concentration does not exceed 1,000 pCi/liter.

However, a water supply may be approved when the limits prescribed above are exceeded if it can be demonstrated by surveillance that the total intake of radioactivity from all sources is within the guidance recommended by the Federal Radiation Council for control action. When mixtures of radionuclides are present, the relative contribution of each radionuclide to the total intake of the individual should be considered when evaluating the exposure.

Table 1 indicates all analytical determinations as reported by the examining laboratory. Table 2 is a summary of the five types of analysis listed in table 1.

Table 2. Drinking water analysis program, 1961–1966 summary of data

Radioactivity	Number of analyses	Concentration range (pCi/liter)
Strontium-90	98	0.0–10.0
Dissolved alpha	232	.0–19.9
Suspended alpha	222	.0–10.3
Dissolved beta	364	.1–45.0
Suspended beta	348	.0–35.0

REFERENCES

(*1*) DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, PUBLIC HEALTH SERVICE. Federal Register Rules and Regulations, Title 42, Public Health Chapter 1, Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards: 2154–2155 (March 6, 1962).

(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. (September 1961).

(*3*) PUBLIC HEALTH SERVICE. Radioactivity in drinking water, 1961. Rad Health Data 3:157–158 (May 1962): 254–255 (August 1962): 411–412 (October 1962); 4:37–39 (January 1963).

(*4*) PUBLIC HEALTH SERVICE. Drinking water quality of selected Interstate carrier water supplies, 1960–1961. PHS Publication 1049 (June 1963).

(*5*) PUBLIC HEALTH SERVICE. Drinking water quality of selected Interstate carrier water supplies, 1962–1963, PHS Publication 1049–A (1965).

(*6*) PUBLIC HEALTH SERVICE. Water supply data. Unpublished reports prepared by the Water Supply and Sea Resources Program.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
HASL Fallout Network	January–June 1967	March 1968
HASL 80th Meridian Network	Calendar year 1965	January 1967

1. Radiation Alert Network April 1968

National Center for Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate National Center for Radiological Health officials by mail or telephone, depending on levels found. Compilation of the daily field estimates is reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique during April 1968. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting stations.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, April 1968

Station location		Number of samples		Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation			
								Total depth (mm)	Field estimation of deposition [b]		
		Air	Pptn	Maximum	Minimum	Average [a]			Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	28	3	4.49	0.45	1.84	Nov 67	68	3	68	7
Alaska:	Adak	4		1.10	.36	.55	Apr 68	(c)			
	Anchorage	20	2	.00	.00	.00	Dec 67	7	2	7	0
	Attu Island	(b)					May 68	(c)			
	Fairbanks	(b)					Jan 68	(c)			
	Juneau	20	14	.34	.00	.01	Feb 68	213	14	213	0
	Kodiak	29		.80	.00	.21	Mar 68	(c)			
	Nome	(b)					July 68	(c)			
	Pt. Barrow	30		1.25	1.08	1.16	June 68	(c)			
	St. Paul Island	30		.44	.43	.44	Aug 68	(c)			
Ariz:	Phoenix	22		9.42	.18	4.35	Feb 68	(c)			
Ark:	Little Rock	9	2	1.88	.31	1.12	Dec 67	36	0	0	(c)
Calif:	Berkeley	22	1	.74	.00	.32	Mar 68	9	1	9	0
	Los Angeles	22	1	1.93	.37	.97	July 68	10	1	10	0
C. Z:	Ancon	16		3.65	2.15	2.73	Mar 68	(c)			
Colo:	Denver	21	3	5.69	.69	2.13	Mar 68	43	(d)	(d)	(d)
Conn:	Hartford	20	6	.28	.22	.24	Jan 68	38	6	38	0
Del:	Dover	20		1.85	.29	.68	Nov 67	(c)			
D. C:	Washington	26	6	5.00	.00	1.15	June 68	26	5	23	0
Fla:	Jacksonville	22	2	2.14	.32	.63	Dec 67	29	0	0	(c)
	Miami	15	1	1.25	.16	.48	Jan 68	8	1	8	0
Ga:	Atlanta	21	8	1.62	.78	1.05	Aug 68	159	0	0	(c)
Guam:	Agana	12		.52	.17	.37	Nov 67	(c)			
Hawaii:	Honolulu	30	3	.89	.29	.54	May 68	75	(d)	(d)	(d)
Idaho:	Boise	22	2	4.89	1.19	2.86	May 68	16	2	16	0
Ill:	Springfield	20	3	6.26	.14	1.76	June 68	25	0	0	(c)
Ind:	Indianapolis	18	5	2.82	1.44	1.95	Aug 68	107	5	107	207
Iowa:	Iowa City	19	6	5.93	.75	2.06	Mar 68	67	1	14	0
Kans:	Topeka	21	8	3.79	.25	1.36	Dec 67	92	8	92	0
Ky:	Frankfort	8	1	.90	.58	.76	June 68	2	1	2	4
La:	New Orleans	21	6	1.99	.32	.70	June 68	90	(d)	(d)	(d)
Maine:	Augusta	21	9	1.31	.09	.65	July 68	85	9	85	0
Md:	Baltimore	20	4	1.56	.26	.98	Jan 68	25	4	25	11
	Rockville	(b)					May 68	(c)			
Mass:	Lawrence	16	5	1.72	.00	.56	Nov 67	60	0	0	(c)
	Winchester	21	7	2.64	.00	.67	Apr 68	45	7	45	0
Mich:	Lansing	11	5	2.38	.75	1.33	May 68	19	5	19	72
Minn:	Minneapolis	21	7	.86	.16	.29	Nov 67	88	7	88	92
Miss:	Jackson	16	5	1.64	.54	.89	July 68	81	3	57	63
Mo:	Jefferson City	21	7	2.52	.35	1.05	Aug 68	81	7	81	0
Mont:	Helena	19	5	3.12	.32	1.20	Apr 68	34	5	34	64
Nebr:	Lincoln	20	5	4.73	.73	1.98	Aug 68	37	5	37	0
Nev:	Las Vegas	5		2.71	.17	1.31	Jan 68	(c)			
N. H:	Concord	21		1.57	.38	.98	June 68	(c)			
N. J:	Trenton	19	2	1.24	.04	.61	July 68	19	2	19	0
N. Mex:	Sante Fe	22	4	1.39	.20	.62	Apr 68	14	4	14	6
N. Y:	Albany	22	3	2.13	.19	.80	Aug 68	32	2	31	28
	Buffalo	20		4.98	.31	.89	Mar 68	(c)			
	New York City	21		.93	.19	.39	Apr 68	(c)			
N. C:	Gastonia	16	7	13.24	1.09	4.58	Mar 68	43	(d)	(d)	(d)
N. Dak:	Bismarck	19	1	4.87	.44	1.47	June 68	19	0	0	(c)
Ohio:	Cincinnati	21		2.75	.35	1.34	Nov 67	(c)			
	Columbus	20	7	2.92	.41	1.12	July 68	78	3	26	0
	Painesville	15	8	2.45	.38	.98	Jan 68	79	8	79	51
Okla:	Oklahoma City	17	2	4.69	.31	.95	May 68	35	2	35	19
Okla:	Ponca City	21	7	2.40	.00	.96	Jan 68	93	7	93	0
Ore:	Portland	22	12	.91	.00	.34	Aug 68	56	12	56	0
Pa:	Harrisburg	15		3.84	.60	1.28	Aug 68	(c)			
P. R:	San Juan	(b)					July 68	(c)			
R. I:	Providence	20	1	.33	.28	.30	May 68	24	0	0	(c)
S. C:	Columbia	19	6	1.61	.06	.64	Apr 68	30	0	0	(c)
S. Dak:	Pierre	10		4.91	.26	1.46	Feb 68	(c)			
Tenn:	Nashville	18	7	1.95	.34	.84	May 68	92	7	92	0
Tex:	Austin	18	6	6.35	1.22	2.74	Nov 67	71	(d)	(d)	(d)
	El Paso	21	2	4.70	1.57	2.57	June 68	2	2	2	0
Utah:	Salt Lake City	28	10	2.28	.57	1.12	July 68	81	0	0	(c)
Vt:	Barre	21	7	2.85	.24	.98	Dec 67	63	7	63	1
Va:	Richmond	16	8	.84	.35	.63	Dec 67	55	2	25	0
Wash:	Seattle	24	8	.73	.00	.03	Dec 67	38	(d)	(d)	(d)
	Spokane	22		3.15	.75	1.58	Nov 67	(c)			
W. Va:	Charleston	8	11	2.01	.26	.75	Apr 68	81	11	81	73
Wisc:	Madison	21	9	1.98	.19	.55	Dec 67	113	9	113	142
Wyo:	Cheyenne	20	4	4.84	.69	1.69	Jan 68	53	3	52	24
Network summary		1,316	274	13.24	0.00	1.12		55	5	50	23

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period
[b] No report received. (Air samples received without field estimate data are not considered by the data program).
[c] No precipitation samples collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are performed on the sample.
[e] Samples were collected but no field estimates were reported.

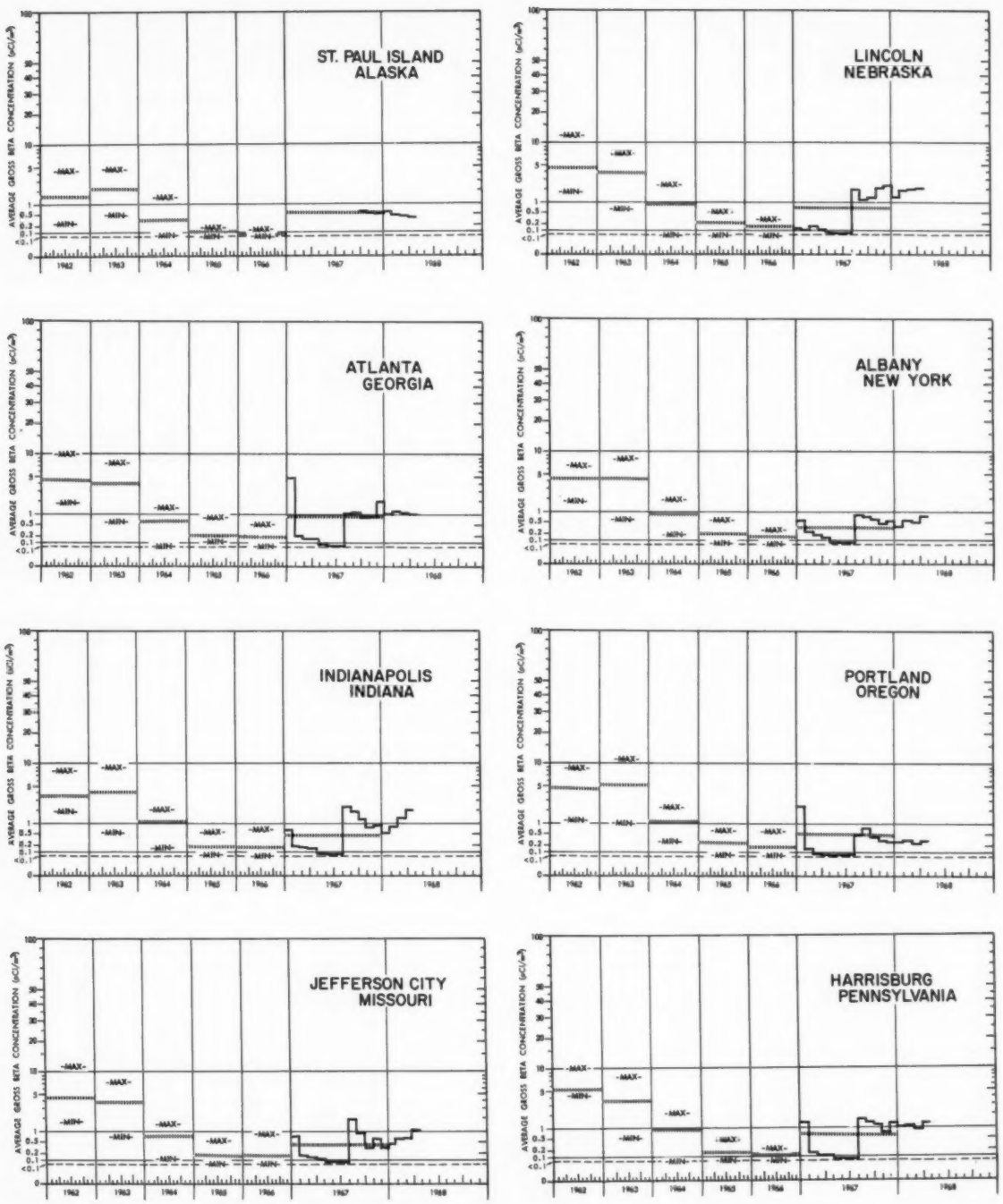

Figure 2. Monthly and yearly profiles of beta radioactivity in Air—Radiation Alert Network, 1962–April 1968

2. Canadian Air and Precipitation Monitoring Program, April 1968[1]

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the July 1968 issue of *Radiological Health Data and Reports*.

[1] Prepared from information and data in the May 1968 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for April 1968 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, April 1968

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	30	0.4	0.0	0.2	NS	NS
Coral Harbour	30	.2	.1	.1	23	1.3
Edmonton	30	.6	.1	.2	44	1.0
Ft. Churchill	30	.4	.1	.2	80	0.9
Ft. William	29	.3	.1	.2	130	9.6
Fredericton	30	.3	.0	.2	88	4.5
Goose Bay	30	.2	.1	.1	46	3.1
Halifax	30	.4	.0	.2	140	9.8
Inuvik	30	.2	.0	.1	77	1.2
Montreal	29	.6	.0	.3	78	4.7
Moosonee	30	.5	.0	.2	38	3.2
Ottawa	24	.4	.0	.2	132	5.0
Quebec	30	.3	.1	.2	61	5.2
Regina	30	.5	.1	.2	229	0.7
Resolute	28	.3	.1	.1	17	.1
St. John's, Nfld	30	.3	.0	.1	94	5.9
Saskatoon	30	.5	.0	.2	19	0.5
Saulte Ste Marie	28	.5	.0	.2	54	5.1
Toronto	30	.4	.0	.2	53	1.3
Vancouver	30	.5	.0	.1	131	4.3
Whitehorse	5	.2	.0	.1	84	0.5
Windsor	30	.4	.1	.2	157	7.2
Winnipeg	29	.4	.1	.2	89	2.9
Yellowknife	30	.3	.1	.2	12	0.2
Network summary		0.6	0.0	0.2	82	3.4

NS, no sample.

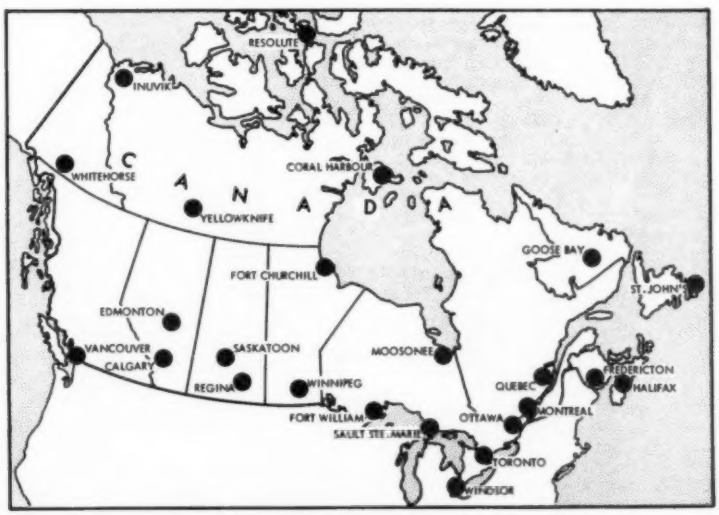

Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program April 1968

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6 by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20 hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental,

Table 4. Mexican gross beta radioactivity in airborne particulates, April 1968

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	13	1.1	0.1	0.4
Chihuahua	14	1.2	.3	.6
Ciudad Juárez	2	0.8	.1	—
Ensenada	NS	NS	NS	NS
Guadalajara	NS	NS	NS	NS
Guaymas	NS	NS	NS	NS
La Paz	9	1.1	.1	.9
Matamoros	NS	NS	NS	NS
Mazatlán	NS	NS	NS	NS
Mérida	4	1.0	.2	.6
México, D. F.	9	2.1	.1	.5
Nuevo Laredo	NS	NS	NS	NS
San Luis Potosí	NS	NS	NS	NS
Tampico	18	.7	.1	.3
Torreón	17	.5	.1	.3
Veracruz	2	.3	.1	—

NS, no sample, temporarily shut down.

Figure 4. Fallout network sampling stations in Mexico

CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month were needed to get a reliable average radioactivity at each station (*7*).

The maximum, minimum, and average beta radioactivity in surface air during April 1968 are presented in table 4.

4. Pan American Air Sampling Program April 1968

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling locations are shown in figure 5. Analytical techniques were described in the January 1968 *Radiological Health Data and Reports*. The April 1968 air monitoring results from the participating countries are given in table 5.

Figure 5. Pan American Air Sampling Program stations

Table 5. Gross beta radioactivity in Pan American surface air, April 1968

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	17	0.03	0.01	0.02
Bolivia: La Paz	19	.05	.01	.02
Chile: Santiago	28	.03	.01	.02
Colombia: Bogota	20	.04	.00	.02
Ecuador: Guayaquil	17	.06	.02	.04
Jamaica: Kingston	17	.48	.21	.30
Peru: Lima	12	.03	.01	.02
Venezuela: Caracas	8	.43	.01	.13
West Indies: Trinidad	18	.26	.06	.13
Summary	156	0.48	0.00	0.07

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

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(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual Report of 1959 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

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(*5*) BEALE, J., and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*6*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare. Ottawa, Canada (August 1962).

(*7*) VASQUEZ, M., and R. M. De NULMAN. Estudios sobre la radioactividad ambiental en la República Mexicana, 1963–1965. Comisión Nacional de Energía Nuclear, Dirección General de Sequridad Radiológica (1966).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling. Alaskan surveillance and environmental monitoring around nuclear facilities.

Iodine–131 in Bovine Thyroids, January–March 1968

National Center for Radiological Health
Public Health Service

The National Center for Radiological Health established a bovine thyroid network in October 1964 (*1*). Specimens are collected by the Livestock Slaughter Inspection Division, U.S. Department of Agriculture, and are analyzed by gamma-ray spectroscopy for iodine–131 content at the Northeastern Radiological Health Laboratory, Winchester, Mass.

The network consists of collection areas (counties shaded in figure 1) located so as to cover, as nearly as possible, areas near major nuclear test sites. Details of sampling and analyses have been published earlier (*1*).

The results for January through March 1968 appear in table 1 and are listed chronologically within each State. Moderate elevations in radioactivity were found in 8 States during parts of January and February. The most active sample analyzed was collected in Brule County, South Dakota on January 24th and contained 83 pCi iodine–131/g thyroid.

REFERENCE

(*1*) BARATTA, E. J., E. R. WILLIAMS, and G. MURRAY. Iodine–131 in bovine thyroids, October–December 1964. Radiol Health Data 6:569–571 (October 1965).

Figure 1. Counties sampled in bovine thyroid network, January–March 1968

Table 1. Iodine–131 in bovine thyroids, January–March 1968

State	Date(s) of slaughter	County	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
Arizona	1/5	Maricopa	2	ND	ND	11
	1/10		2	6		
	[a] 1/19–3/28	Maricopa (18) [c]	20	[b] ND		
		Santa Cruz (2)				
California	1/4–3/29	Fresno (1) [c]	7	[b] ND		
		Kings (1)				
		San Joaquin (1)				
		San L. Obispo (1)				
		Santa Barbara (1)				
		Los Angeles (2)				
Georgia	1/2	Cherokee	2	1	ND	2
		Gilmer	1	ND		
		Lumpkin	2	5	2	8
		Union	3	1	ND	3
		White	2	2	ND	3
	1/15	Washington	10	10	ND	20
	1/25	Bibb	3	2	ND	5
		Columbia	4	4	ND	7
		DeKalb	3	26	ND	42
	1/29	Screven	4	8	ND	22
		Washington	6	2	ND	7
	2/6	Forsyth	2	27	8	45
		Walton	3	15	ND	39
	2/13	Emanuel	2	5	3	6
		Laurens	3	10	5	16
	2/20	Barrow	2	9	7	11
		Forsyth	3	9	ND	16
		Laurens	3	2	ND	3
	2/28	Bibb	3	1	ND	3
	2/29	Butts	2	ND		
		Screven	2	ND		
		Wilkes	3	5	3	8
	[a] 3/7–3/27	Bartow (5)	38	[b] ND		
		Bibb (8)				
		Butts (3)				
		Candler (3)				
		Clarke (4)				
		DeKalb (2)				
		Forsyth (2)				
		Glascock (2)				
		McDuffie (3)				
		Screven (6)				
Idaho	[a] 1/19–3/22	Ada (2) [c]	18	[b] ND		
		Canyon (4)				
		Gem (2)				
		Owyhee (5)				
		Shoshone (4)				
		Washington (1)				
Iowa	2/27	Lyon	6	ND		
	3/27	Lyon	3	2	ND	3
Kansas	1/10	Douglas	1	ND		
	1/24	Johnson	1	10		
Louisiana	1/5	Bossier	1	10		
	1/12	DeSoto	1	7		
	1/24	Bossier	1	10		
	3/6	Claiborne	1	ND		
	3/13	Claiborne	1	ND		
Minnesota	2/20	Rock	4	ND		
New York	[a] 1/11–2/21	Chatauqua [c]	30	[b] ND		
North Carolina	1/10	Cleveland	2	39	22	55
	2/20	Cleveland	2	12	9	15
Oklahoma	1/3	Carter	1	ND		
	1/15	Choctaw	1	68		
	1/17	Jefferson	1	ND		
	1/19	McCurtain	1	42		
	2/2	Carter	1	50		
	2/6	Carter	1	52		
	3/15	Beyan	1	ND		
Oregon	1/19	Malheur	1	ND		
South Carolina	1/10	Aiken	1	ND		
		Barnwell	1	10		
		Orangeburg	4	8	ND	16
		Spartanburg	1	43		
	2/7	Bamberg	2	ND		
		Orangeburg	3	7	2	9
	2/13	Bamberg	3	2	ND	3
		Colleton	2	ND		
	3/27	Richland	2	2	2	2

See footnotes at end of table.

State	Date(s) of slaughter	County	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
South Dakota	1/2	Aurora	5	1	ND	4
		Jones	2	2	ND	3
	1/3	Aurora	2	ND		
	1/23	Tripp	1	ND		
	1/24	Brule	9	41	5	83
	1/29	Tripp	9	14	3	54
	1/30	Minnehaha	1	ND		
	2/7	Aurora	1	21		
		Brookings	1	4		
		Brule	1	ND		
	2/8	Charles Mix	5	9	ND	14
	2/12	Tripp	3	2	ND	5
	2/14	Brule	7	3	ND	18
	2/20	Brule	1	15		
		Davison	2	4	3	4
	2/22	Brule	2	8	ND	16
		Charles Mix	1	9		
	2/27	Minnehaha	3	ND		
	3/4	Corson	2	ND		
	3/4	Tripp	5	2	ND	7
	3/5	Lincoln	1	9		
	3/5	Minnehaha	1	4		
	3/12	Charles Mix	10	ND		
	3/19	Brookings	10	ND		
	3/26	Davison	3	2	ND	3
	3/27	Lincoln	2	1	ND	2
Tennessee	1/4	Blount	4	3	ND	13
		Monroe	1	ND		
		Sevier	1	ND		
	1/11	Blount	2	29	22	36
		Knox	1	ND		
		Monroe	1	5		
		Sevier	1	4		
	1/18	Blount	2	9	5	13
		Knox	1	ND		
		McMinn	1	40		
	1/25	Blount	1	ND		
		Fentress	1	7		
		Knox	1	8		
	2/2	Blount	1	5		
		Knox	3	13	4	18
	2/8	Blount	2	7	5	8
		Loudor	1	8		
		Sevier	1	3		
	2/20	Blount	3	11	ND	34
	[a] 2/21–3/27	Anderson (1) [c] Blount (5) Cumberland (2) Grainger (1) Jefferson (1) Knox (9) Roane (3) Sevier (1)	23	[b] ND		
Texas	1/3	Denton	1	ND		
	1/30	Denton	1	39		
	2/6	Hopkins	1	10		
	2/12	Denton	1	49		
	2/13	Cooke	1	35		
	2/14	Denton	1	41		
	2/23	Hopkins	1	ND		
	2/28	Hopkins	1	ND		
	2/29	Titus	1	ND		
	3/6	Denton	1	10		
	3/12	Denton	1	8		
	3/18	Hopkins	1	9		
	3/27	Hopkins	1	ND		
Vermont	[a] 1/9–3/30	Franklin [c]	60	[b] ND		
Washington	1/5	Walla Walla	1	ND		
Wisconsin	[a] 1/11–3/13	Dane (14) [c] Green (2) Rock (24) Sauk (5)	45	[b] ND		

[a] Samples were not collected on all dates during this period, but the interval includes several sampling dates.
[b] The results for this period were for the most part not detectable. Some randomly scattered positive results were obtained; but these represented barely detectable amounts of iodine-131 in the bovine thyroid (2 to 5 pCi/g).
[c] Numbers in parentheses represent the number of samples collected from that county during the interval indicated. These may have been collected over several dates or on only one date.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Argonne National Laboratory and Feed Materials Production Facility.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Argonne National Laboratory July–December 1967[2]

University of Chicago
Lemont, Illinois

The radioactivity of the environment is determined on a continuing basis by measuring the radioactivity in naturally-occurring materials collected both on and off the Argonne National Laboratory site. Since radioactivity is usually spread by air and water, the environmental monitoring program at Argonne has concentrated on these materials. The sampling locations discussed in this report are shown in figures 1 and 2.

Air monitoring

Air-filter samples were collected continuously at seven locations on the Argonne site and at five locations off the site. The alpha and beta radioactivity in air-filter samples are summarized in table 1. The alpha radioactivity concentrations were normal both on and off the site and in the range found in previous years. The beta radioactivity was presumed to result from fission and neutron-activation products from nuclear detonations. The decrease in beta radioactivity during the year was due to the disappearance from the atmosphere of the shorter-lived fission products, such as barium–lanthanum–140, cerium–141, iodine–131, and zirconium–niobium–95. The latter pair of radionuclides reappeared during the last 4 months of the year, concentrated in a few discrete particles on each filter paper sample in which it was present in above normal amounts. This behavior is attributed to insoluble particulate fallout from the stratosphere. The average beta radioactivity for the year, 0.11 pCi/m^3, was 0.04 pCi/m^3 less than during 1966. The similarity between alpha, beta, and fission product activities on and off the site indicates that Argonne did not add significantly to the particulate airborne activity of the environment. Significant releases by Argonne would have been detected in the form of an increase in the onsite activity over the offsite activity.

Sampling on charcoal, specifically for gaseous radioiodine was conducted continuously on the site. Iodine–131, released from building 330, was detected beginning September 20 at a maximum concentration of 0.3 pCi/m^3, or 0.3 percent of the AEC standards. This activity diminished to 0.1 pCi/m^3 one week later, and remained at that level for several weeks. Detectable surface deposition of radioiodine from this release was confined to 100 yards of the building. None was detected off the site.

[2] Summarized from "Environmental Radioactivity at Argonne National Laboratory, July–December and Annual Summary 1967," University of Chicago, Lemont, Ill.

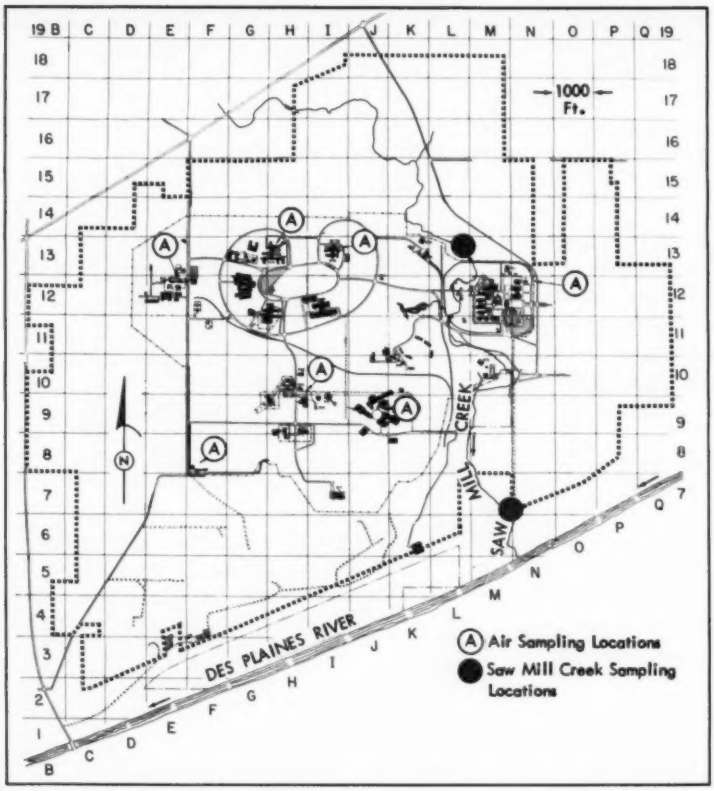

Figure 1. Sampling locations on the site of Argonne National Laboratory

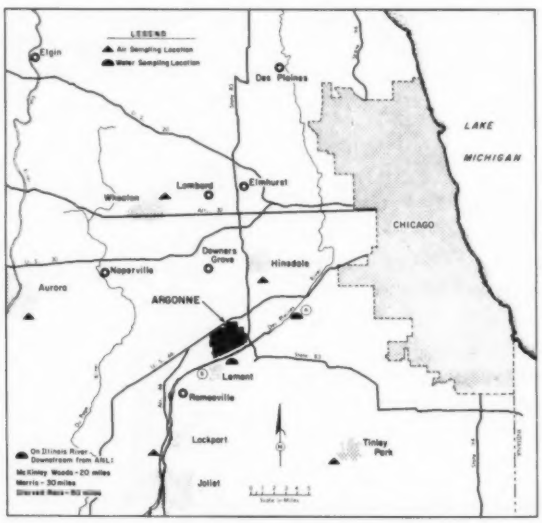

Figure 2. Site location of Argonne National Laboratory (including some offsite sampling stations)

Table 1. Alpha and beta radioactivity in air-filter samples, Argonne National Laboratory,[a] July–December and annual summary 1967

Period (1967)	Location	Number of samples	Alpha radioactivity (pCi/m^3) multiply by 10^{-4}			Beta radioactivity (pCi/m^3)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July	onsite	27	0.50	0.23	1.16	0.04	0.03	0.06
	offsite	17	.48	.17	.61	.05	.02	.09
August	onsite	27	.48	.21	1.14	.04	.03	.08
	offsite	22	.53	.27	.96	.04	.03	.08
September	onsite	24	.56	.21	1.21	.04	.02	.06
	offsite	22	.67	.31	1.57	.04	.02	.07
October	onsite	20	.40	.19	.80	.05	.02	.52
	offsite	22	.38	.17	.81	.04	.02	.08
November	onsite	19	.34	.16	.56	.04	.02	.10
	offsite	21	.41	.19	1.00	.05	.02	.12
December	onsite	20	.35	.20	.55	.06	.02	.11
	offsite	22	.35	.16	.70	.05	.02	.20
July–December	onsite	137	0.44	0.16	1.21	0.04	0.02	0.52
	offsite	126	0.47	0.16	1.57	0.04	0.02	0.20
Annual summary	onsite	238	0.43	0.16	1.21	0.11	0.02	1.14
	offsite	256	0.46	0.16	1.57	0.12	0.02	1.45

[a] These results were obtained by measuring the samples 4 days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron decay products.

Water monitoring

Argonne wastewater is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters the Des Plaines River about 500 yards downstream from the wastewater discharge. Sawmill Creek was sampled above and below the discharge to evaluate the effect of the wastewater on the radioactivity in the creek. The sampling locations are shown in figure 2.

Below the wastewater outfall the creek was usually sampled three times weekly. Since it was impractical to analyze all the samples for all the nuclides and elements desired, equal portions of the three samples collected each week were combined and analyzed. The results obtained in this way represent the average concentrations in the weekly samples. Above the site, samples were collected at weekly intervals, and at least one sample each month was analyzed for each radioactive nuclide of interest. The total alpha and beta radioactivities found in Sawmill Creek during the second half of 1967 are given in table 2.

The alpha-particle emitters most likely to be present in Argonne wastewater are isotopes of uranium, plutonium, and thorium. The alpha radioactivity in the creek water due to these elements are summarized in table 3. The average uranium concentrations below the outfall was about 20 percent higher than during 1966 while the plutonium and thorium concentrations this year averaged less than the minimum detectable amount.

Table 2. Non-volatile alpha and beta radioactivity in Sawmill Creek water, Argonne National Laboratory, July–December and annual summary 1967

Month (1967)	Location [a]	Number of samples	Alpha radioactivity (pCi/liter)			Beta radioactivity (pCi/liter)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July	Upstream	2	0.7	0.6	0.9	7.4	6.5	8.4
	Downstream	12	1.3	.8	2.0	26	15	44
August	Upstream	2	1.4	.8	2.1	17	13	21
	Downstream	12	4.6	2.7	9.3	19	14	29
September	Upstream	2	5.0	4.0	6.0	30	22	38
	Downstream	15	2.3	1.0	6.5	21	16	31
October	Upstream	2	2.5	1.7	3.2	15	12	17
	Downstream	12	2.2	1.0	2.8	15	12	20
November	Upstream	2	2.3	2.3	2.3	9	7.7	11
	Downstream	12	2.8	2.1	3.8	13	9.2	18
December	Upstream	2	3.5	3.0	4.0	7.7	6.9	8.6
	Downstream	15	2.5	2.2	4.1	13	10	15
Annual summary	Upstream	23	2.4	0.6	6.0	13	3.0	38
	Downstream	156	2.4	0.3	9.3	21	8.7	86

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

Table 3. Alpha-emitting elements in Sawmill Creek water Argonne National Laboratory, July–December 1967

Element	Location [a]	Number of samples	Concentration (pCi/liter)			Average as a percent of AEC standard
			Average	Minimum	Maximum	
Uranium	Upstream	12	1.9	0.7	2.7	0.005
	Downstream	75	1.6	.6	6.0	.004
Plutonium	Upstream	6	—	—	<.05	—
	Downstream	36	.05	<.05	.16	.001
Thorium	Upstream	6	—	—	.05	—
	Downstream	36	<.05	<.05	.06	<.003

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

Table 4. Average radioactivity in Des Plaines and Illinois River water, Argonne National Laboratory, July–December 1967

Location	Concentration (pCi/liter)	
	Non-volative alpha radioactivity	Non-volative beta radioactivity
Des Plaines River [a] (above Sawmill Creek)	4.4	14
Des Plaines River [b] (below Sawmill Creek)	3.2	13
Illinois River [c]	3.2	8

[a] Sampled near Route 45, upstream from the mouth of Sawmill Creek.
[b] Sampled near Lemont, downstream from the mouth of Sawmill Creek.
[c] Sampled at McKinley Woods State Park, Starved Rock State Park, and Morris, on October 18, 1967.

In addition to the natural beta radioactivity in the creek, beta radioactivity from fallout was detected at both sampling locations and beta radioactivity from Argonne wastewater was found in some samples below the outfall. The natural beta radioactivity is approximately 5 pCi/liter above the site and 3 pCi/liter below the site. The Argonne contribution to the total beta radioactivity below the outfall during the second half of 1967 is estimated to be approximately 10 pCi/liter, about one-fourth of the 1966 value.

Since Sawmill Creek empties into the Des Plaines River, which in turn flows into the Illinois River, the radioactivity in the latter two streams is important in assessing the contribution of Argonne wastewater to the environmental radioactivity. The Des Plaines River was sampled monthly above, and weekly below, the mouth of Sawmill Creek to determine if the radioactivity in the creek had any effect on the radioactivity in the river. The total radioactivity is summarized in table 4. The average concentrations were very similar at both locations, indicating that Sawmill Creek water had no significant effect on the radioactivity in the river. The alpha and beta radioactivities were not significantly different from the 1966 averages. The natural beta radioactivity in the river is 5 to 10 pCi/liter, and the additional radioactivity, about 7 pCi/liter on the average was due to fallout.

The Illinois River was sampled at McKinley Woods, Morris and Starved Rock State Park on October 18. The total radioactivity in these samples were similar to those found in other bodies of water in the area and to the radioactivity found previously at these same locations. No radioactivity originating at Argonne was detected in the Des Plaines or Illinois Rivers.

Radioactivity in milk

Raw milk was collected monthly from a local dairy farm and analyzed for several fission products. Barium–140, strontium–89, and iodine–131 were not present in concentrations greater than the minimum detectable amounts of 20 pCi/liter for iodine–131 and 3 pCi/liter for the other two nuclides. The cesium–137 and strontium–90 concentrations are given in table 5. These two nuclides are long-lived fission products from past nuclear tests and their presence in milk is not related to Argonne operations. The strontium–90 concentrations averaged approximately 1.5 pCi/liter less than during 1966, while the cesium–137 content was about 40 pCi/liter higher than the 1966 average.

Table 5. Fission product concentrations in milk July–December 1967

Collection date 1967	Concentrations (pCi/liter)	
	Cesium-137	Strontium-90
July 5	125	7.6
August 2	148	5.4
September 6	86	7.0
October 5	103	4.8
November 2	50	6.0
December 6	90	10.2
Average	100	6.8

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December and annual summary	September 1967
January–June 1967	March 1968

2. Feed Materials Production Center July–December 1967[a]

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the AEC. The location as related to populated areas is shown in figure 3. Cincinnati and Hamilton, the larger nearby communities, are situated 20 and 10 miles from the center, respectively. Operations at this project deal with the processing of high-grade uranium ores and ore concentrates to produce metallic uranium and with fabricating the metal into fuel elements.

During the many involved reactions and processes that lead to the production of reactor fuels, various liquid and airborne wastes are generated. These wastes contain varying quantities of uranium. Various in-plant methods are used to curtail their release into the environment surrounding the plant. Almost complete removal of the materials is accomplished by using dust collectors and waste treatment processes. In order to determine what concentrations reach the area surrounding the project an environmental survey program has been established which consists of wastewater, soil, and air sampling of the environs and performing those analyses on the samples that are indicative of material released from the plants.

Onsite air samples are obtained from four permanent perimeter air sampling stations, located at the four corners of the production area as shown in figure 4. Samples from these perimeter stations are collected once each week and analyzed for uranium and total radioactivity. Offsite samples are collected by a mobile air sampling unit. The location at which samples are collected is determined by local meteorological conditions on the day of sampling. Approximately 20 percent of all samples are taken upwind of the FMPC plant. Replicate samples are taken at each sampling point and averaged to obtain a representative concentration for that location. Concentrations of uranium and total radioactivity of airborne particulates sampled at onsite and offsite locations are given in table 6.

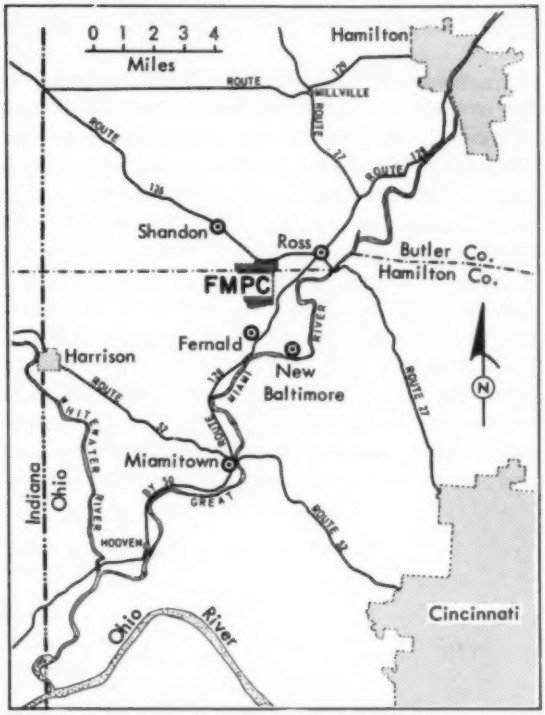

Figure 3. Area map of Feed Materials Production Center

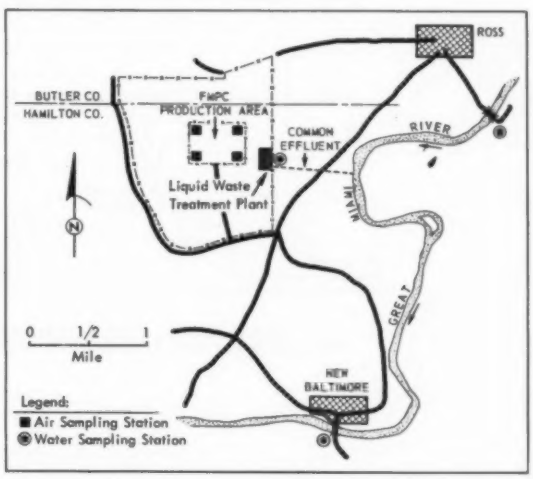

Figure 4. Air and water sampling stations, FMPC

[a] Summarized from "Feed Materials Production Center Environmental Monitoring Semiannual Report for the Second Half of 1967, Summary Report for 1967," (NLCO–1013).

Water monitoring

Each of the individual production plants on the project has collection sumps and treatment equipment to remove the uranium from the process waste water. The effluent from the plants are collected at a general sump for equalization and settling. The clear water from the sump is pumped to the river. The solid portion is pumped to a chemical waste pit for further settling. The flow, which is decanted to the clear well portion of the pit, is virtually free of solids and radioactivity. The effluent from the sump and clear well are combined with waste water from the FMPC water treatment plant, sanitary sewage treatment plant, and storm sewerage system and discharged via a common effluent outfall into the Great Miami River. A weir-type water sampler collects samples of the combined effluent stream, which are removed and analyzed daily. These results are utilized with measurements of river flow in calculating the radioactive contaminant concentrations added to the river. Weekly spot samples are also obtained upstream and downstream from the common FMPC effluent at locations shown in figure 4. The results of the FMPC water monitoring program for July–December 1967 are summarized in table 7.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1966	August 1967
January–June 1967	March 1968

Table 6. Radioactivity levels of airborne particulates, Feed Materials Production Center, July–December 1967

Location	Number of samples	Uranium concentration [a] (pCi/m³)			Total radioactivity [b] (pCi/m³)		
		Maximum	Minimum	Average	Maximum	Minimum	Average
Onsite:							
Southwest	25	0.7	<0.1	0.1	1.8	<0.1	0.3
Northwest	25	.4	< .1	< .1	0.8	< .1	.1
Northeast	25	.4	< .1	.1	1.0	< .1	.2
Southeast	25	.5	< .1	.1	.8	< .1	.2
All onsite samples	100	.7	< .1	.1	1.8	< .1	.2
Offsite:							
0–2 miles from FMPC	55	1.1	< .1	.1	3.5	.1	.4
2–4 miles from FMPC	25	1.1	< .1	.2	2.1	< .1	.5
4–8 miles from FMPC	24	.2	< .1	< .1	.4	< .1	.1
8–12 miles from FMPC	12	< .1	< .1	< .1	< .1	< .1	< .1
All offsite samples	116	1.1	< .1	.1	3.5	< .1	.3

[a] AEC radiation protection standard–2 pCi/m³.
[b] AEC radiation protection standard–100 pCi/m³.

Table 7. Radioactivity in the Great Miami River, Feed Materials Production Center July–December 1967

Location	Number of samples	Uranium concentration [a] (pCi/liter)			Total radioactivity [b] (pCi/liter)		
		High	Low	Average	High	Low	Average
Sewer outfall	184	<10	<10	<10	170	<10	160
Upstream from outfall	25	<10	<10	7	210	<10	30
Downstream from outfall	29	60	<10	10	90	<10	40

[a] AEC radiation protection standard–20,000 pCi/liter.
[b] AEC radiation protection standard–3,000 pCi/liter.

Reported Nuclear Detonations, July 1968

The U.S. Atomic Energy Commission announced that the United States recorded seismic signals originating north of the Caspian Sea on July 1, 1968. The signals were equivalent to those of a nuclear test in the low-intermediate range (20–200 kilotons TNT equivalent).

Announcement was also made by the U.S. Atomic Energy Commission that a nuclear test of low-intermediate yield (20 to 200 kilotons TNT equivalent) was conducted underground at its Nevada Test Site on July 30, 1968.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

LEVELS OF IRON–55 IN HUMANS, ANIMALS, AND FOOD, 1964–1967. *H. E. Palmer, J .C. Langford, T. M. Beasley, C. E. Jenkins, and J. M. Aase. Radiological Health Data and Reports, Vol., 9, August 1968*, pp. 387–390.

Iron–55 levels in the foods of humans have been decreasing since 1964 with the exception of caribou obtained from Arctic areas, which showed peak levels in 1965. The levels of iron–55 in humans at Richland, Wash., increased until about January 1967, and then began to decrease. This peak level in humans occurred about 4 years after the 1962 nuclear test series. This lag time of 4 years is much longer than that for cesium–137 in humans where peak levels occurred 1½ years after the nuclear tests stopped.

KEYWORDS: Body burdens, fallout, fish, foods, humans, human food chain, iron–55, nuclear tests.

CESIUM–137 LEVELS IN FLORIDA BEEF — VARIATIONS WITH FEEDING PROGRAM. *C. E. Roessler, B. G. Dunavant, H. A. BEVIS, and G. S. Roessler. Radiological Health Data and Reports, Vol., 9, August 1968*, pp. 391–396.

Levels of cesium–137 in low quality lean beef samples, collected in the vicinity of Gainesville, Fla., in the spring of 1967, averaged 4,000 pCi/kg and ranged from 290 to 12,500 pCi/kg. The average and maximum levels in these samples from eight grass-fed animals were considerably higher than those in samples from 26 grain-fed animals from five peninsular Florida feed lots. The levels in the grass-fed animals suggest very high levels of cesium–137 intake by the animals, an extremely high feed-to-meat transfer, or both. For persons whose meat consumption is represented by the grass-fed animals examined in this study, it can be expected that meat exceeds all other commodities as the source of cesium–137 intake.

KEYWORDS: Beef, cesium–137, feeding program, Florida, grain-fed, grass-fed.

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